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MANUAL

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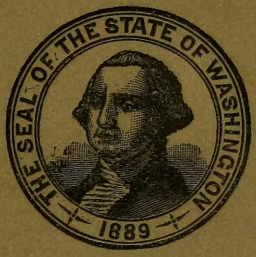
HORTICULTURE



MANUAL

—OF—

HORTICULTURE

—FOR—

Grade and High Schools

—BY—

S. S. BUSCH, B. S.

—AND—

E. E. GUSTIN, B. S.

In

Agriculture and Horticulture

'08, of W. S. C.

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EXPLANATION.

1. The manual is intended for the second year of high school, but it can readily be used in other grades: first semester to page 99; second semester, manual completed.
2. The aim is not only to give an outline of the principal subjects of horticulture, arranged according to seasons, but also to explain and illustrate each subject.
3. Further help is given by referring to a number of reference books and bulletins.
4. Each school should have all the given references referred to in the manual.
5. All the essential statements that each pupil finds when reading should be copied in a note book and referred to at the time of the recitation.

ACKNOWLEDGEMENT.

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   a. A. L. Melander and H. B. Humphrey of the Washington State College for permitting the use of the Sulphur-lime Calendar and Orchard Spray Calendar.
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   e. American Book Company for cuts from the following books:
      1. Andrews' Botany, cuts 3, 4, 6, 55, 56, 57, 60, 61, 62, 63, 68, 70, 71, 72.
      2. Agriculture by Goff and Mayne for cuts 23, 30, 31, 69.
   f. The Macmillan Company for cuts from the following books:
      1. Principles of Agriculture by Bailey, cuts 24 to 29.
      2. Fruit Growing in Arid Regions by Paddock and Whipple, cuts 41, 43, 45, 79, 89, 90, 93, 96, 109, 110.
      3. Pruning Book by Bailey, cuts 85 to 88, 101, 102, 105, 106.
   g. United States Department of Agriculture for cuts 32 to 40, 42, 44, 46, 48 to 54, 58, 59, 64 to 67, 75, 76, 78, 80 to 84, 91, 92, 94, 95, 112, 113, 116 to 129, 133, 137, 138, 140, 148, 149, 153, 154, 155, 157, 159, 160, 161.

STRUCTURE OF BLOSSOMS

AND

SETTING OF FRUITS

1. **The fruit buds** on opening in the spring release one or more blossom buds.
   a. For the formation of fruit buds—see buds.
2. The blossom bud consists of floral envelopes and organs of reproduction.
3. The structure of an apple blossom—see flower.
   a. **The floral envelopes.**
      1. c—calyx, which is the outer green covering of the buds; its parts are sepals.
      2. pt—corolla, which is the inner colored, showy covering of the bud; its parts are petals.
      3. The calyx and corolla may be taken off and still it is possible for the fruit to develop.

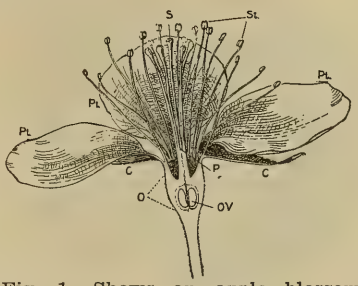


Fig. 1.—Shows an apple blossom. (N. Y. Exp. Station.)

   b. **Organs of reproduction.**
      1. st—stamens are the thread-like organs that produce the pollen.
      2. p—pistil is the ovule-bearing or seed-bearing organ.
         a. Stigmatic surface which is the rough, sticky surface of the stigmas.
         b. o—ovary, which has five cavities, each containing two ovules.
         c. ov—ovules, which develop into seeds when fertilized.

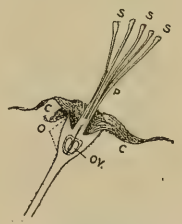


Fig. 2.—Shows apple blossom with the corolla and stamens removed. (N. Y. Exp. Station.)

4. **Setting of fruit.**
   a. It is caused by the union of two elements.
      1. Nucleus of a plant cell borne in the pollen grain.
      2. Egg cell borne in the ovary.
   b. The stamens produce the pollen, which must reach the stigmatic surface of the pistil, either by insects or in some other way.
   c. When the stigmatic surface is ready to receive the pollen, it becomes covered with a sticky fluid which easily holds any of the pollen that happens to touch it.
   d. The pollen in a few hours after it reaches the stigmatic surface, sprouts and sends tubes down through the soft tissues of the style to the ovules.
   e. Through these tubes there passes into the ovary a substance

which stimulates the ovules to growing into a seed, or in other words, which fertilizes them.

f. Fruit is, "The ripened ovary with its attachments."

5. **Sections of apples**

a. c—carpels.

b. f — fibrovascular bundles.

c. pl—placenta.

d. p—peduncle.

e. s—seeds.

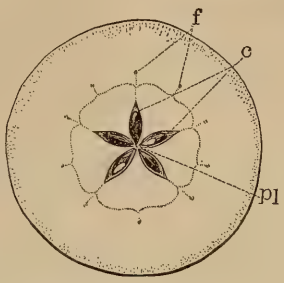


Fig. 3.—Cross section of an apple. (Andrew's Botany.)

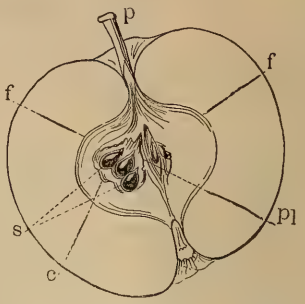


Fig. 4.—Vertical section of an apple. (Andrew's Botany.)

6. **Vascular system of an apple.**

a. The vascular system has numerous sets of vessels or ducts that begin in the stem and extend to all parts of the apple.

b. The ducts are food-conducting vessels.

c. The fungus diseases follow the ducts from the rind to the core, and from core to rind.

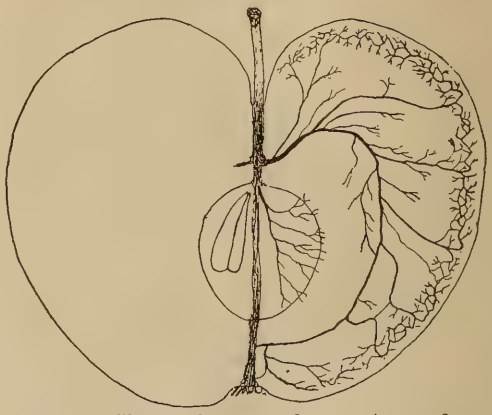


Fig. 5.—Shows the vascular system of an apple. (N. Y. Exp. Station.)

7. Study the structure of the blossoms and setting of fruits of the different kinds of fruits in the spring.

DESCRIPTION OF THE POME FRUIT.

1. **The Forms.**
   a. The horizontal diameter is the distance from cheek to cheek at the widest point.
   b. The vertical diameter is the distance from stem to blossom.
   c. **Kinds of forms.**
      1. Round form when the two diameters are about equal.
      2. Oblong or long form when the vertical diameter is longer than the horizontal diameter.
      3. Oblate or flat form when the vertical diameter is distinctly shorter than the horizontal diameter.
      4. Conic form when the apple tapers toward the blossom end.
      5. Other forms; as, oblong-conic, round-oblate, round-conic, oblique, regular and irregular.

d. **Sizes of each variety.**
   1. Small, medium, large and very large.

e. **Cavities.**
   1. Stem end.
      a. Shallow, medium or deep.
      b. Narrow or medium broad.
      c. Abrupt, rounded or sloping.
      d. Smooth, regular, irregular or wavy.
   2. Blossom end.
      a. Long or small.
      b. Open, half open, or closed.

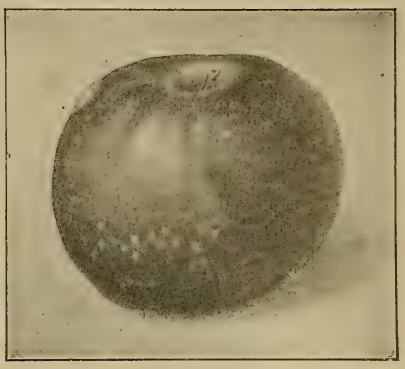


Fig. 6.—Shows the lenticels on the skin.

f. **Color, Fig. 6.**
   1. Blush on cheek.
   2. Washed all over.
   3. Striped color.
   4. Solid color.
   5. Dots or lenticel.
      a. White, gray or russet.
      b. Round or irregular.
      c. Sunken, raised or scattered

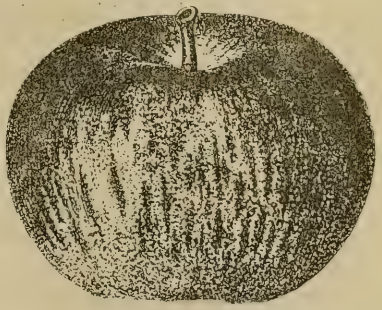


Fig. 7.—Shows a well-formed apple.

g. **Skin.**
   1. Thin, thick, tough, or brittle.

h. **Flesh.**
   1. Hard, soft, coarse, fine, crisp, spongy or woody.
   2. Dry, juicy, acid, sub-acid, flat or sweet.

i. Each fruit should be studied as it is very important that the quality of each be known.
   1. Use "Systematic Pomology" by Waugh.
   2. "Fruit Growing," by Paddock and Whipple.

PICKING.

1. **Time to pick.**
   a. Perishable fruits.
   b. Depends on varieties.
   c. Distance to market.
   d. Period of organization.
      1. No marked lines between greenness and immaturity.
      2. No marked lines between ripeness and maturity.
      3. No marked lines between maturity and decay.
      4. One stage passes into the other insensibly.

2. **Classification.**
   a. **Rules for picking apples.**
      1. General rules.
         a. Pick when seeds begin to turn a light brown and before they become dark around the edges.
         b. Pick when the color characteristic of variety has developed; as, Fameuse and McIntosh.

c. Pick when the fruit yields slightly to pressure.
d. Pick when the stems readily separate from the spurs.

2. Red apples are commonly gauged by their color.
3. Red apples are sometimes left on trees after the seeds indicate maturity to allow them to put on more color which they readily do under the influence of the bright days and frosty nights.
4. Yellow apples are gauged by the color of the seeds.
5. The picking after the seeds indicate ripeness, invites water core, and shortens the life of the fruit in storage.
6. Apples that develop no red color are picked when full size, or begin to soften or part readily from the spurs.
7. Early picking reduces the loss from wind storms and wind falls.
8. Picking over the tree twice.
   a. First, taking off such apples that are well colored and up to size.
   b. Second, taking off those that have developed since first picking.
9. Properly developed and well colored apples stand cold storage better.
10. The hand should grasp the apple cautiously with the forefinger at the stem and by a twist of the wrist, given with an upward or downward movement, unjoints the stem from the fruit spur.
11. Apples should not be grabbed and jerked off or shaken down nor clubbed off.
12. Careless picking destroys many fruit spurs and injures the fruit by bruising.
13. The fruit will not keep so well if the stems are pulled out, the skin broken, or flesh bruised.
14. Some varieties, as Jonathan, should be picked before fully ripe to prevent rotting at the core.

b. **Rules for picking pears.**

1. Some gather the fruit as soon as the seeds turn brown, if the shipment is any distance.
2. The pear should be perfectly green and hard.
3. The pears should be picked before they reach the stage of golden color.
4. Determined by separating the fruit from the stem.
   a. The stems should easily part from the limbs by twisting or turning the fruit from the natural position with thumb and forefinger; or,
   b. Grasping the pear in the hand and turning it in an opposite direction from which it hangs.
   c. If they part from the twig easily, they are ready to pick.
5. The size of the fruit is not a safe guide because young trees and old trees with light crops will produce larger fruit than old trees heavily loaded.
6. The proper size for a Bartlett pear is 2¼ inches; Comice, much larger; Winter Nellis, smaller.

7. Pears should be picked before fully ripe to prevent rotting at the core, or hard woody granules forming in them.
8. The pears, when picked, should be wrapped and stored in a moderately cool, dark place to ripen; but not in piles.

c. **Rules for picking quinces.**
1. They should be gathered when they begin to turn yellow.
2. They must be handled with great care.

d. **Rules for picking peaches.**
1. Distant shipments—the peach must be picked while still firm, but should be fully grown and well colored.
2. The greenness on the lighter side should be very dim.
3. The peach must reach the market just as it is in condition to use.
4. Local market—the peach may be allowed to begin to ripen on the tree.
5. Early morning is a better time to pick peaches because the cooler the fruit is kept while in packing house and transit, the better condition it will be in when the destination is reached.

e. **Rules for picking plums.**
1. Plums will bear picking when decidedly green.
2. Local market—they should be allowed to hang as long as possible except for jelly making.
3. Many ripen very nicely after being picked and keep for three or four weeks in moderately cool, dark places and come out ripe and juicy.
4. For long distance shipping, peach plums need not be colored, but there must be a light yellow spot appearing on one side or they will not color up when they ripen.

f. **Rules for picking cherries.**
1. They are generally picked just before they ripen and the best test for ripeness is to eat a few.
2. They should be handled with great care.
3. The stems should be left on and only the stems touched with fingers.
4. Use an 8-pound basket in picking.
5. The bottom fruit in the basket should never be pressed too heavily.
6. The fruit spurs should not be pulled off.

g. **Rules for picking apricots.**
1. See peaches.
2. For long distance shipping, apricots need not be colored, but there must be a light yellow spot appearing on one side or they will not color up when they ripen.

h. **Rules for picking strawberries.**
1. Berries must be pink all over or three-fourths red.
2. Berries should be picked riper in cool weather than warm weather.
3. Berries should be picked with stems, breaking them off a fourth to one-half inch above fruit.
4. Berries should be picked greener for shipping, than home market.

5. Berries must not be picked while there is moisture on the vines.
6. Pickers must not hold several berries in their hands at the same time.

i. **Rules for picking raspberries.**

1. Red raspberries are picked as soon as they begin to soften slightly.
2. Black raspberries are picked as soon as they will part from the receptacle.
3. Raspberries are picked and put into pint boxes, which are placed in hand carriers which contain six boxes and carried direct to packing house.

j. **Other rules.**

1. Blackberries and dewberries are usually picked when they are evenly colored.
2. Gooseberries are picked while yet quite green.
3. Currants are allowed to color but are picked before they are ripe.

3. **Picking receptacles.**
   a. Baskets.
   b. Galvanized buckets of 12 to 14-quart size.
   c. Stout wire hook.
4. **Essential points in handling.**
   a. Avoid bruising the fruit.
   b. Avoid breaking the skin of the fruit.
   c. Avoid sudden cooling of the fruit.
   d. Avoid leaving fruit in piles or letting stand in the sun in the orchard.
   e. Secure a good storage house at temperature from 30° to 35° F.
5. **Picking with stems off or on.**

Picked with stems on		Picked with stems off	
Apples	Pears	Raspberries	Peaches
Plums	Quinces	Blueberries	Apricots
Cherries	Grapes	Juneberries	Tomatoes
Currants	Gooseberries	Blackberries	
Strawberries	Persimmons		

6. **Benefit with stems.**
   a. Prevents the juice escaping.
   b. Prevents the moistening of the packages
   c. Checks the decay of fruits.
   d. Acts as packing material.
   e. Aids in looks.
7. **Conveniences for picking.**
   a. Picking shears.
   b. Step-ladders with three legs.
   c. Low wagons.
8. **Managing pickers.**
   a. Daybook system.
   b. Check system.
   c. Punch-card system.

9. **Questions.**
   a. How should an apple be grasped to take it from stem?
   b. What effect on the fruit system to jerk the fruit off?
   c. Should there be more than one picking?
   d. What is a good picking receptacle?
   e. Why is early morning the best time to pick fruit?
10. **References.**
   a. Fruit Harvesting, Sorting, and Marketing, by Waugh.
   b. Fruit Growing by Bailey.
   c. Fruit Growing by Paddock and Whipple.
   d. Maryland Bulletins Nos. 144, 160, 159.
   e. Iowa Bulletin No. 114.
   f. Idaho Bulletin No. 70.
   g. Get rules from different Fruit Associations.

GRADING.

1. The general rule is to sort each variety into two or three grades, and two sizes to each grade.
2. It takes more experience and better judgment for grading than picking or packing.
3. The sorting and packing tables should be conveniently arranged to facilitate the work.
4. Pickers should be required to empty the fruit carefully into apple boxes by hand, and should look for bruised and blemished fruit which should be put in piles under the shaded sides of the trees to be disposed of as soon as possible.
5. The fruit so assorted may then be stored in the storing house for packing.
6. The requirement of uniformity is the one chiefly to be considered in handling fruit.
7. The different grades of winter apples.
   a. **Extra fancy.**
      1. Each specimen must be a well formed, fully matured apple, free from insect pests, worms, worm stings, scale, scab, sun scald, dry rot, water core, or other defects; limb rubs, skin puncture, or other evidences of rough handling will be considered defects.
      2. Solid red varieties.
         a. Like Spitzenberg, Winesap, Arkansas Black, Gano, Jonathan, Missouri Pippin, etc., must have 75 per cent red.
      3. Partially red or striped varieties.
         a. Like Ben Davis, Delicious, Rome Beauty, Baldwin, Wagner, Stayman Winesap, and other varieties of similar color, must be at least 50 per cent of good color.
      4. Red cheek or blush varieties.
         a. Like Red Cheek Pippin, Winter Banana, etc., must have a distinctly colored cheek.
      5. Green or yellow varieties.
         a. Like Grimes Golden, Yellow Newton, White Winter Pearmain, etc., must show a good bright color.
      6. No greater count than 200 will be accepted except sometimes Missouri Pippin and Winesap may be packed as small as 225.

7. Boxes lined and apples wrapped.

b. **Fancy.**

1. This grade shall consist of well formed, fully matured apples, free from insect pests, worms, worm stings, scale, scab, sun scald, dry rot, water core, or other defects; limb rub, skin puncture, or other evidences of rough handling will be considered defects.
2. Solid red varieties.
   a. Same as extra fancy, must at least be 25 per cent (by some associations 33 1-3 per cent.) of good natural color.
3. Partially red or striped varieties.
   a. Same as extra fancy, must be at least 10 per cent (some fruit associations 20 per cent.) of good red color.
4. Red cheek varieties.
   a. Physical qualities must be good; no requirements as to color.
5. Green or yellow varieties.
   a. No requirements as to color.
6. No greater count than 175 will be accepted; except—
   a. Newton Pippins, Missouri Pippins and Winesaps may be packed up to 200 inclusive.
7. Boxes lined and apples wrapped.

c. **C Grade.**

1. All merchantable apples not included in the Extra Fancy or Fancy grades will be accepted in this grade.
2. Each apple to be free from worm holes, scale or other infectious diseases; but no mis-shapen apples or limb rub, or other like defects will be accepted.
3. No requirements as to color except the fruit must be clearly mature.
4. No count greater than 163.

8. **The different grades of summer apples.**

a. **Extra Fancy.**

1. The same as Extra Fancy grade of winter apples, except color is eliminated.
2. All apples wrapped.

b. **Fancy.**

1. The same as Fancy and C grades of winter apples.
2. Color is eliminated.
3. All apples wrapped.

9. **Different grades of pears.**

a. **Extra Fancy.**

1. This grade shall consist of pears not less than 2¼ inches in diameter (except Winter Nellis which shall not be less than 1¾ inches).
2. This grade shall be free from worms, scale, all bruises and defects, mis-shapen or limb rubs.
3. Pears without stems will not be accepted.

b. **Fancy.**

1. See Extra Fancy.
2. This grade shall be free from worms, scale and bruises, but mis-shapen, limb rubs, or other defects will be accepted.

3. The stems or part of the stems must be on the pears.

10. **The grading of peaches.**
   a. The excellence of the pack depends upon uniform grading.
   b. No over-ripe, undersized, immature, bruised, mis-shapen, diseased, wormy, or defective fruit should be packed.
   c. Note: Over-ripe peaches may be packed for special purposes.
   d. Peaches less than two inches in diameter should not be packed for shipment.

11. **The grading of plums, prunes, and apricots.**
   a. They should be free from worms, bruises, punctures, or other defects.

12. **The grading of cherries.**
   a. They should be in perfect condition; right degree of ripeness.
   b. There should be no stemless cherries.

13. **The grading of strawberries.**
   a. No green, over-ripe, stemless, undersized, or mis-shapen berries should be packed.
   b. Varieties like the Hood River or Clark's Seedling should be pink all over and must be not less than 75 per cent red when picked.
   c. Varieties like Nick Ohmer should be red all over.
   d. The Glen Mary should be picked before it acquires the full red color all over, but not less than half of the berry should be well colored.
   e. **Grades of strawberries.**
      1. **First or "A" grade.**
         a. Berries of good size, well colored, firm and clean.
         b. Cups filled solidly, faced on top, no stems showing.
         c. Berries smaller than five across the cup should not be packed.
      2. **Second or "B" grade.**
         a. This grade includes unpacked, unfaced, or undersized berries when well colored, firm, clean, and otherwise same as first grade.
      3. **Third or "C" grade.**
         a. This grade includes all merchantable berries excluded from the first and second grades.

14. **The grading of raspberries.**
   a. All broken, crushed or over-ripe berries should be thrown on the ground or put in a separate box for home or cannery use.
   b. Raspberries should be picked as soon as they will slip off the core without crumbling or mashing.
   c. Over-ripe berries must not be put into the cup; one over-ripe berry will cause mould in the cup; one mouldy cup will destroy a crate; a bad crate will spoil a carload.
   d. The Cuthbert Raspberry cannot be picked until it is all red, and should be picked before it turns dark; Antwerp Red Raspberries can be picked before entirely red, but do not pick them until half the berry is red and the balance pink, but do not pick with any part of the berry green.
   e. Pickers should use small carriers attached to the waist, and as

quickly as the berry is removed from the bush, it must be put in the carrier and not held in the hand.

f. Berries will lose their strength and be crushed if held in the hand.

15. **The grading of Evergreen blackberries.**
    a. The unripe berries will turn red the day after they are picked, and are only fit for cannery purposes.
    b. Every berry should be deposited in the cup as quickly as picked.
    c. No berry moulds as fast as the Evergreen.
    d. Every broken seedpod means a mouldy berry.
    e. The berries must be picked directly into the cups, and not transferred from one cup to another.
    f. Keep carriers and all berries out of the sun and dust.
    g. Evergreen berries must be picked every day, or at least every other day, so as to get them off the vines at the proper time.
    h. A ripe berry is much larger than an unripe berry and takes less to fill the cup.
    i. They should be taken off the vines as quickly as they become sweet.
    j. Cover the berries in the wagons to protect from sun and dust.

PACKING.

1. Packing is the classification of fruits into their proper sizes and the placing of the same size solidly into boxes in such a manner as to insure uniformity of appearance, neatness, and protection from bruising.
2. **Packing house.**
    a. Composed of a packing room and store room.
    b. Center opening between the packing and the store rooms.
    c. Packing tables should be equipped with places for:
        1. Cardboard which is a thin piece of pasteboard 11x17½ inches, used in top and bottom, inside of the lining paper.
        2. Lining paper, which is 18x26 inches.
        3. Wrapping paper.
            a. Size of paper 12x12 inches for 64 apples and larger.
            b. Size of paper 10x10 inches for 72 apples to 96 apples.
            c. Size of paper 9x9 inches for 100 apples to 175 apples.
            d. Size of paper 8x8 inches for 188 apples and smaller.
3. **Boxes for packing.**
    a. **Apples.**
        1. Northwest Standard box.
            a. Size 10½x11½x18 inches inside dimensions containing 2173.5 cubic inches.
        2. Thickness of lumber in boxes.
            a. End boards should be at least ¾ inch in thickness.
            b. Side boards should be ⅜ inch in thickness.
            c. Side boards should be of one piece.
            d. Top and bottom boards should be of two pieces, each ¼ inch thick.
        3. Two cleats each for top and bottom.
        4. **Lining of box.**
            a. It takes two sheets of lining paper for each box.

b. Lining the left side of the box.
   1. Take a sheet of lining paper and place it over the left side of the box, letting the edge come just past the center of the bottom.
   2. Place the right hand flat on the inside bottom of the box and press hard enough to make an opening between the bottom and the side.
   3. Press the paper out a little way through this opening with the thumb and finger.
   4. This opening will close and catch a fold in the paper when the hand is removed.

c. Lining the right side of the box.
   1. It is done in the same way as lining the left side, except the left hand is used instead of the right hand.
   2. The edges of the lining paper should lap a little in the bottom.

d. The fold is needed in the lining paper to keep it from bursting when nailing up the box, which causes a bulge in the bottom of the box.

e. The layer-board is only used when the apples are very ripe and repacked in the spring.

f. Always pack in clean boxes.

b. **Pears.**
   1. Size 8½x11½x18 inches inside dimensions.
   2. Thickness of lumber.
      a. The end boards should be ¾ inch thick.
      b. The top and bottom boards should be ¼ inch thick.
      c. The sides should be ⅜ inch thick.

c. **Peaches.**
   1. Size 4, 4½, or 5x11½x18 inches inside dimensions.
   2. Thickness of lumber.
      a. The end boards should be 11/16 inch thick.
      b. The top, side and bottom boards should be ¼ inch in thickness.

d. **Prunes.**
   1. Small wood-veneer boxes, each 8 inches square and 4 inches deep.
   2. Size of crate 4½x16x17⅝ inches, except for extreme sizes, then increase or diminish depth of pack only.
   3. Plums and apricots, same as prunes.

e. **Cherries.**
   1. Size of crate 2¼x9x19¾ inches inside dimensions.
   2. The box is generally divided into two equal parts.

4. **Wrapping fruits.**

a. **Apples.**
   1. Place the wrapping paper in the left hand so that the center of the paper is over the palm of the hand.
   2. Pick up the apple with the right hand and place it into the center of the wrapping paper.
   3. The apple should be tossed or slightly thrown into place in order to jerk up the edges of the paper, making it easier to fold around the apple.

4. The stem of the apple should be towards the lower right-hand corner of the paper.
5. Grasp the loose edges of the paper next to the packer with the right hand, turning it to the right enough to fold the paper over the apple.
6. With the fingers of the left hand fold the loose parts of the paper farthest from the packer, giving a slight twist toward the left.
7. Each apple must be completely covered with paper drawn down smoothly.
8. The apple is ready to put into the box when properly wrapped.

b. **Pears.**

1. Place the paper diagonally in the left hand.
2. Pick up the pear with the right hand and slightly throw it into center of paper with stem from the packer.
3. The right hand gathers the lower corners up over the fruit and at the same time giving it a twist which wraps the remainder of the paper around the neck forming a cone-shaped package.
4. Show method.
   a. Place the pear in the corner of the paper nearest to packer.
   b. Grasp the corner and pear with the fingers of the right hand, giving the pear a twist to the right.
   c. This forms a perfect cone.
5. The bottom of the paper is folded under the fruit.
6. Use the proper size paper for the size fruit.

c. **Peaches.**

1. See apples.

5. **Size of fruits.**

a. **Apples.**

1. The sizes are classified into what are called tiers.
2. The size of the apple is determined by its diameter from cheek to cheek at the widest point, never from stem to blossom end.
3. Grouped by tiers.
   a. 3 -tier means the sizes from 36 to 56 inclusive.
   b. 3½-tier means the sizes from 64 to 88 inclusive.
   c. 4 -tier means the sizes from 96 to 125 inclusive.
   d. 4½-tier means the sizes from 138 to 175 inclusive.
   e. 5 -tier means the sizes from 188 to 225 inclusive.

b. **Pears.**

1. Grouped by tiers.
   a. 4-tier means the sizes from 40 to 120 inclusive.
   b. 5-tier means the sizes from 120 to 245 inclusive.

c. **Peaches.**

1. Sizes in packs from 40 to 96 inclusive.

6. **Placing fruit in boxes.**

a. **Apples.**

1. General Rule: Without moving the apple from the left hand after it is properly wrapped, place it in the box, stem toward

the end of the box next to the packer, laying the apples on the fold of paper and on its cheek.
2. Remember that all apples in the same box should be of the same size and packed in the same manner.
3. Never turn the stem of one apple to the cheek of another apple.
4. Very flat apples may be tilted to keep the pack from coming too high at the ends.

b. **Pears.**
1. Begin each pack by placing the blossom end of the pear against the end of the box next to the packer.
2. Place the pears in the second row into the spaces in the first row, with stem ends toward the packer.
3. This will throw the blossom end of the pears to the ends of the boxes.

c. **Peaches.**
1. See apples.
2. Packed with stem ends down in both layers.
3. The peaches should be pressed together tightly enough to give a slight bulge to the sides of the box.
4. Place the larger peaches nearer the center of the box to give a slight bulge to top and bottom.

d. **Prunes.**
1. The way in which the prunes are packed depends on the size.
2. The prunes are best packed with the diagonal pack when they are large enough.
3. The prunes should fill the box and stand high enough to touch the lid.
4. Plums and apricots are similar to the prunes.

e. **Cherries.**
1. The cherries are packed double-faced in bottom of box; then the box filled.
2. No stems should be shown on top; no stemless cherries should be packed.
3. Cherries should be packed with flat or creased side against the boards.
4. Make neat square packs.
5. Nail on top and turn the box over and mark the packed side as top.

f. **Strawberries.**
1. The packers should empty the boxes brought in by the pickers and refill them snugly, but without bruising the berries, so that there will be no settling to destroy the appearance of the pack.
2. The top of the box should be faced with 16, 20 or 25 berries, all of uniform size and color.
3. The boxes should be filled so that the top layer will show three-eighths of an inch above the top of the box.
4. However, care must be exercised so that berries do not extend over the edge of the box, or they will be cut when the cover is nailed on the crate causing discoloration of boxes and hastening decay of berries.

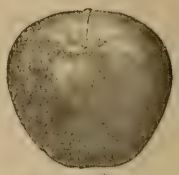
5. Berries brought from the field should be emptied on screens in order to allow the sand and dust to fall away from the fruit.

g. **Raspberries.**
1. See picking.

h. **Blackberries.**
1. See picking.

7. **Diagonal packs.**

a. **Apples.**



1. The apples are so placed that the rows will not run in a straight line from side to side across the bottom of the box.
2. Name of diagonal packs.
   a. **Two-one pack** which is a three layer pack.
      1. The way to start a two-one pack.

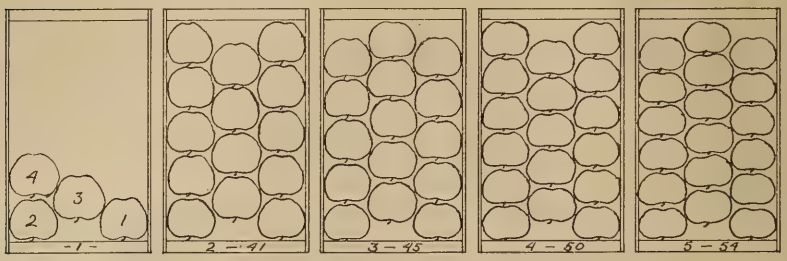


Fig. 8.—Shows how to start a two-one pack.

   a. Place an apple in each corner of the box next to packer, as 1 and 2 of cut No. 1.
   b. Place an apple in the pocket formed by 1 and 2; as, 3 of cut No. 1.
   c. Continue to place apples in the pockets thus formed until the first layer is completed.
   d. Make all the pockets even.
2. Placing the second layer.
   a. The first apple of the second layer is placed in the pocket formed by 1, 2 and 3 of cut No. 1.
   b. Continue to place apples of the second layer in the pockets of the first layer, until completed.
3. Placing the third layer.
   a. The third layer is laid like the first layer.
4. 3-tier counts of the two-one pack.
   a. Tabulated.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
41	5-4	3	2	Large apples.
45	5-5	3	3	Large apples.
50	6-5	3	4	Very flat apples.
54	6-6	3	5	Very flat apples.

5. When the apples are small enough to make a straight row across the end of the box, they are packed into a two-two pack.

b. **Two-two pack** which is a four-layer pack.

1. The way to start a two-two pack.

a. Place an apple in the right-hand corner of box, as 1 of cut No. 6.

b. Place second apple midway between the first apple and side of the box, as 2 of cut No. 6.

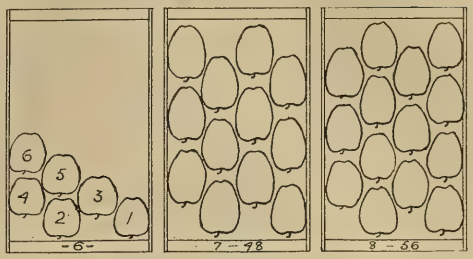


Fig. 9.—Shows how to start a two-two pack.

c. Place two apples in the two pockets formed by the first two apples, as 3 and 4, of cut No. 6.

d. Place the next two apples; as 5 and 6 of cut No. 6.

e. Continue as 7, 8, 9, 10 until first layer is completed.

2. Placing the second layer.

a. Place first apple in the left-hand corner between 2 and 4 of cut No. 6.

b. Place second apple in the pocket of 1, 2 and 3 of cut No. 6.

c. Place the second layer on the first layer and show how the apples of the second layer fit in the pockets of the first layer.

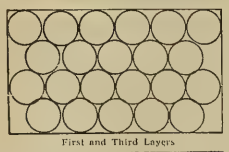
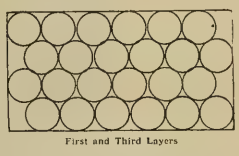


Fig. 10, Two-two pack, 88.



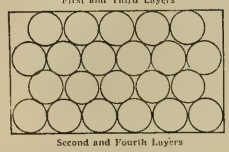
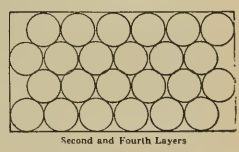


Fig. 11. Two-two pack, 96.



3. Place the third layer on the second and the fourth layer on the third layer, explain.

a. If the first layer is started in the right-hand corner, the second layer would be started in the left-hand corner.

4. The first and third layers; second and fourth layers of a two-two pack are the same—Figures 10 and 11.

5. 3-tier counts of the two-two pack.

a. Tabulated.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
48	3-3	4	7	Long apples.
56	4-3	4	8	Medium long apples.

6. 3½-tier counts of the two-two pack.

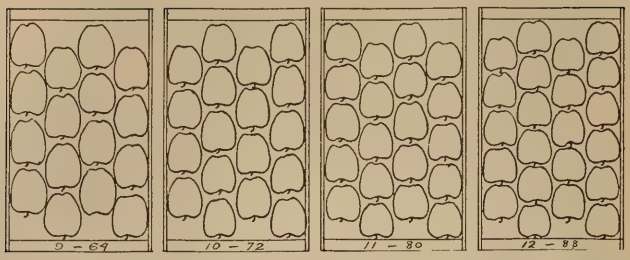


Fig. 12.—Shows the 3½-tier counts of the two-two pack.

a. Tabulated.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
64	4-4	4	9	
72	5-4	4	10	
80	5-5	4	11	
88	6-5	4	12	

7. 4-tier counts of the two-two pack.

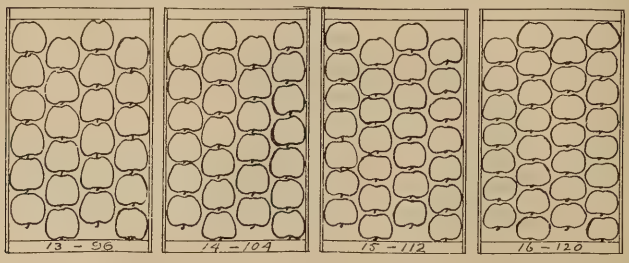


Fig. 13.—Shows 4-tier counts of the two-two pack.

a. Tabulated.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
96	6-6	4	13	
104	7-6	4	14	Flat apples.
112	7-7	4	15	Very flat apples.
120	8-7	4	16	Very flat apples.

8. When the apples are small enough to make a straight row across the end of the box, they are packed into a three-two pack.

c. **Three-two pack** which is a five layer pack.

1. The way to start a three-two pack.

a. Place an apple in each corner of the box next to the packer, as 1 and 2 of cut No. 17.

b. Place an apple in the center be-

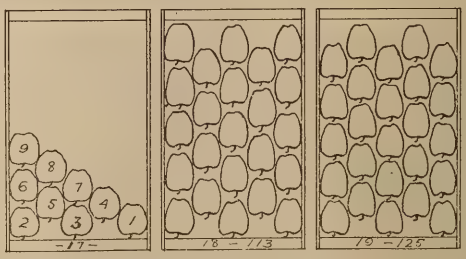


Fig. 14.—Shows how to start a three-two pack.

tween the first two, as 3 of cut No. 17.

c. Continue to place the apples, as 4, 5, 6, 7, 8, 9, of cut No. 17 until the first layer is completed.

2. Placing of the second layer, Fig. 15.
   a. The first apple is placed in pocket formed by 1, 3 and 4 of cut No. 17.
   b. The second apple is placed in pocket formed by 2, 3 and 5 of cut No. 17.
   c. Continue placing the apples of second layer in the pockets of the first layer until completed.

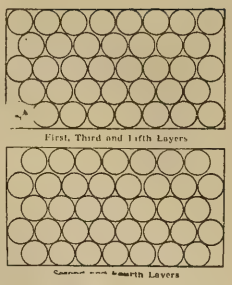


Fig. 15, Three-two pack, 188.

3. The third layer is placed like the first layer; the fourth like the second; the fifth like the first layer.
4. 4-tier counts of the three-two pack.
   a. Tabulated.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
113	5-4	5	18	
125	5-5	5	19	

5. 4½-tier counts of the three-two pack.

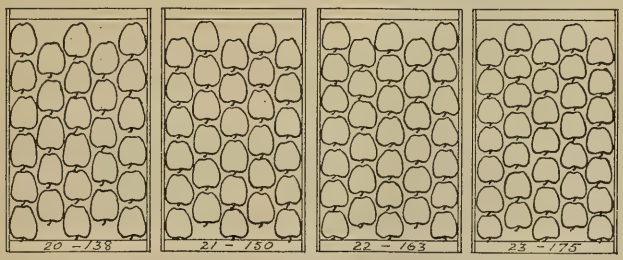


Fig. 16.—Shows the 4½-tier counts of the three-two pack.

a. Tabulated.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
138	6-5	5	20	
150	6-6	5	21	
163	7-6	5	22	
175	7-7	5	23	Packed also in 5-tier

7. The 5-tier counts of the three-two pack.

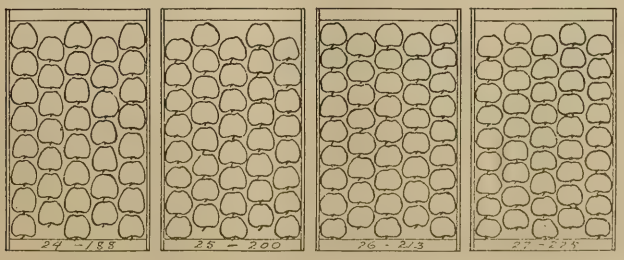


Fig. 17.—Shows the 5-tier counts of three-two pack.

a. Tabulated.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
188	8-7	5	24	
200	8-8	5	25	Very flat apples
213	9-8	5	26	Very flat apples
225	9-9	5	27	Very flat apples

9. When the apples are small enough to make a straight row across the end of the box, they are packed into a three-three pack.

d. **Three-three pack** which is a six layer pack.

1. The way to start a three-three pack.

a. Place the first apple in the right hand corner of the box next to the packer; as 1 of cut No. 28.

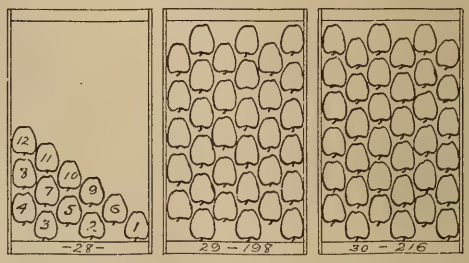


Fig. 18.—Shows how to start a three-three pack.

b. Place the second apple 1/3 of the remaining distance; as 2 of cut No. 28.

c. Place the third apple ½ of the remaining distance; as 3 of cut No. 28.

d. Place the three apples in the pockets formed in the first row; as 4, 5, 6 of cut No. 28.

e. Continue in the same manner until the first layer is completed.

2. Place the apples of the second layer in the pockets of the first layer.

3. If the first layer begins in the right-hand corner, the second layer should begin in the left-hand corner, etc.

4. 5-tier counts of the three-three pack.

a. Tabulated.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
198	6-5	6	29	Long apples.
216	6-6	6	30	

5. Very rare diagonal pack.

No. in Box	No. in Rows	No. of Layers	Name of Pack	Remarks
36	4-4	3	2-1	Very large apples.
100	4-4	5	3-2	Very long apples.

b. **Pears.**

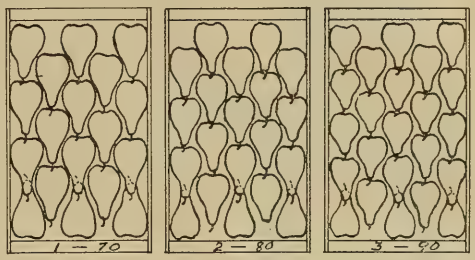
1. **Names of diagonal packs.**

a. **Three-two pack** which is a four layer pack and called 4-tier pack.

1. See apple.

Fig. 19.—Shows the way to start a three-two pack (a); three-three pack (b); four-three pack (c).

2. Place the pears as 1, 2, 3, 4, 5, 6, 7, 8, 9 of cut A in Fig 19.
3. Place blossom ends of 1, 2 and 3 against end of box.
4. Reverse the pears by placing the stem ends toward the packer.
5. Placing the second layer.
   a. Place the pears of second layer in the pockets of the first layer.
   b. Place blossom ends of the first row of second layer to end of box then reverse and place stem ends toward the packer.



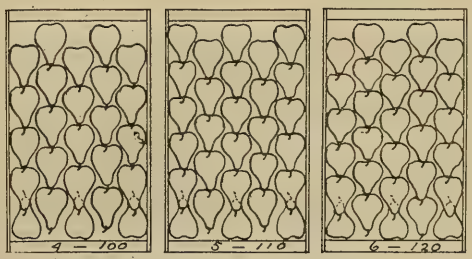


Fig. 20.—Shows the 4-tier counts of the three-two pack.

6. The third layer is laid like the first; fourth layer is laid like the second.
7. 4-tier counts of the three-two pack.
   a. Tabulate.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
70	4-3	4	1	
80	4-4	4	2	
90	5-4	4	3	
100	5-5	4	4	
110	5-6	4	5	
120	6-6	4	6	

8. When the pears are small enough to make a straight row across the end of the box, they are packed into a three-three pack.

b. **Three-three pack** which is a 5 layer pack and called 5-tier pack.

1. Place the pears as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 of cut B in Fig. 18.
2. Place other layers.
   a. See 3-2 pack.
3. 4-tier counts of the three-three pack.

Fig. 21.—Shows the 5-tier counts of the three-three pack.

a. Tabulate.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
120	4-4	5	7	
135	5-4	5	8	
150	5-5	5	9	
165	6-5	5	10	
180	6-6	5	11	

5. When the pears are small enough to make a straight row across the end of the box, they are packed into the four-three pack and called a five-tier pack.

c. **Four-three pack** which is a five layer pack.

1. Place the pears as 1, 2, 3, etc., of cut C in Fig. 19.
2. Place other layers.
   a. See 3-2 pack.
3. 5-tier counts of the four-three pack.

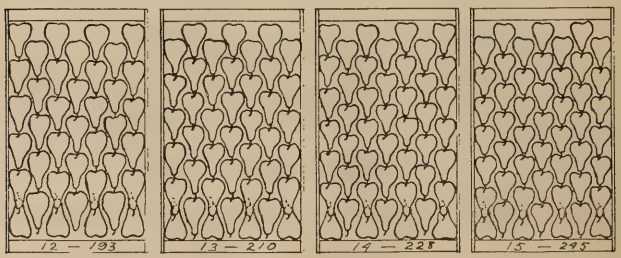


Fig. 22.—Shows the counts of the four-three pack.

a. Tabulated.

No. in Box	No. in Rows	No. of Layers	No. of Cut	Remarks
193	6-5	5	12	
210	6-6	5	13	
228	7-6	5	14	
245	7-7	5	15	

c. **Peach.**

1. **Diagonal pack of peaches.**

a. There are only two layers in a box of peaches.
b. Peaches less than two inches should not be packed.
c. Pack the stem ends down in both layers.
d. The Elbertas should not be less than 2¼ inches in diameter.
e. The peaches in a box should not vary more than one-eighth of an inch in diameter.
f. All grades must be carefully wrapped in suitable paper.
g. **Three-two pack** which is a two-layer pack.
1. Pack peaches between 2½ and 3 inches in diameter in this pack, in 4½-inch boxes.
2. Start the three-two pack of peaches the same as a three-two pack of apples.
3. Place the peaches in second layer in the spaces between the peaches in the first layer.
4. The counts of the three-two pack.
a. Tabulated.

No. in Box	No. in Rows	No. of Layers	Remarks
40	4-4	2	
45	5-4	2	
50	5-5	2	
55	6-5	2	
60	6-6	2	
65	7-6	2	
70	7-7	2	
75	8-7	2	

i. **Three-three pack** which is a two layer pack.
1. Pack peaches between 2 and 2½ inches in diameter in this pack, in 4-inch and 4½-inch boxes.
2. Start the three-three pack of peaches, the same as a three-three pack of apples.
3. Place the peaches in second layer in the spaces between the peaches in the first layer.
4. The counts of the three-three pack.
a. Tabulated.

No. in Box	No. in Rows	No. of Layers	Remarks
78	7-6	2	
84	7-7	2	
90	8-7	2	
96	8-8	2	

d. **Prunes, plums and apricots.**

1. Tabulated.

Name of Pack	No. in Rows	No. of Layers	Remarks
3-2	3-4	2	Diagonal pack.
3-2	3-3	2	Diagonal pack.
	4-4	2 or 3	Square pack.
	5-5	3	Square pack.
	5-6	3	Square pack.
	6-6	3	Square pack.

e. **Cherries.**
1. 9-row, 10-row, 11-row, 12-row, solid pack.
2. They are packed in a square pack.
3. They are packed double-face in the bottom of the box.
4. The flat or creased side of the cherry rests against the boards.
5. Then the cherries are poured into the remaining space.
6. After the top is nailed on, the pack is turned over and marked.

8. **Making the bulge.**

a. **Apple.**
1. The bulge is best obtained by packing the apples a little closer in the center of the box than at the ends.
2. When the apples are packed closer in the center than the ends, the pockets between the center apples are smaller and the apples of the second layer will not go so deep in the pockets of the first layer and the center is built up higher.
3. When the ends are left a little more loose than the center, the apples of the second layer drop further into the pockets of the first layer and do not build up so high.
4. Alternating the laying of apples at the end.
   a. It is necessary when apples are very flat, like the Wagner.
   b. One or two apples at ends of each layer are placed flat.
   c. The stem or blossom ends are turned to the top or bottom of the box.
   d. It is easy to determine what apples are to be turned when the first layer is almost completed.
   e. If it is a four layer pack, turn the apples on layers Nos. 1 and 3 on end of layer farthest from packer, and on Nos. 2 and 4 on end nearest the packer.
   f. By alternating, the ends are kept lower, no space left, nicer and closer pack, less liable to bruise the cheeks of end fruit when cover is put on.
5. The packer will soon learn by practice how tight to pack the center and how loose to pack the ends.
6. When the box is finished the end apples should be very little above the head of the box, and the center apples should be 1½ to 2 inches higher than the end apples.
7. This will give from ½ to ¾-inch bulge on both top and bottom, when nailed.
8. Do not select large apples for the center as they will make larger pockets and the next layer will drop down deeper and nothing is gained toward making the bulge.
9. The slight degree irregular apples should be packed at the ends in order to keep the apples low at the end.

b. **Pear.**
1. The center pears should be from 2½ to 3 inches higher than the end pears.
2. Pears packed green will have a big shrinkage which would cause the pears in a flat pack to loosen.
3. Do not pack the first layer too tight, if you do you are sure to make too big a bulge.
4. The end pears should be pressed in toward the center of the box in order to keep the center higher than the ends.

9. **Selection.**
   a. An attractive box is one made up of fruit of the same size for each box.
   b. A fruit of the right size for the box will go in one place just as well as another.
   c. The proper alignment and uniformity is based on nearly the same size fruit for the box.
   d. See grading.
10. **Marking boxes.**
   a. When packed, the number of fruit, the grade and the variety should be stamped on the end of the box.
   b. The grower's name and address are required to be placed on the box.
   c. A neat label adds to the appearance of the package.
11. **Nailing press.**
   a. The best nailing press is one which presses only on the ends of the lid and holds the cleats and top firmly in place until nailed.
   b. There should be places on the press for nails, cleats, tops and rubber stamps.
   c. After the boxes are nailed up, they should always be laid on the sides, as the sides are straight and the fruit is not bruised.
12. **References.**
   a. See picking.

THE RESPIRATION OF APPLES.

1. All living cells, whether a part of animal matter or vegetable matter, must have oxygen to keep them alive and they give up carbon dioxide and water as a result of the action of the oxygen on some of their contents.
2. Parts of plants when cut off from the main stem do not die at once, and must continue to breathe.
3. This is true, whether the severed part is a leafy branch, a fruit, or a root; but some parts live much longer after removal than others, and the apple continues to breathe for many weeks after it has been picked from the tree.
4. The chief products of respiration are the same in plants as in animals, namely, carbon dioxide (commonly called carbonic acid) and water.
5. Respiration, whether in animals or in plants, causes a destruction of matter in the cells much like the destruction of wood in a stove, and the rate at which this destruction goes on can be measured by determining the amount of carbonic acid that is breathed out in a given length of time.
6. In animals, under usual conditions, the food which they eat makes good the losses produced by respiration.
7. An animal, however, may live without food for some time, during which period it still breathes in oxygen and breathes out carbon dioxide and water, but it steadily loses weight and grows thin in flesh because there is a steady destruction of cell material with no food to replace it.
8. Fruit, after having been picked from the tree, is in the condition of the starving animal.

9. Its cells still keep up respiration with nothing in the way of food to make good the losses produced by the action.
10. Apples and other fruits have no body heat to maintain, the breathing process is not so active as in animals, and they may last months after being picked from the tree.
11. There is a steady, continuous loss in weight, although the fruit is sound and firm.
12. Fancy apples intended for long keeping in cold storage should be cooled as soon as possible and kept cold.
13. The breathing process is at the expense of cell contents and must weaken the keeping qualities as it goes on.
14. This destructive action is from four to six times as fast out of cold storage as inside it.
15. The respiration is not stopped in cold storage, but simply slowed.
16. Apples cannot be kept indefinitely, but keep about twice as long in cold storage as in a cool cellar.

Exercise 1.

1. **Object:** To show the respiration of apples.
2. **Method:**
   a. Place one or more apples in a jar and cover it tightly.
   b. In a few hours a dewy film will cover the inner surface of the jar, that in time will collect into drops which will trickle to the bottom.
   c. On opening the jar, a little clear lime water may be poured into it, without touching the fruit.
   d. The lime water will be seen to turn milky.
   e. Just as it will if an animal's breath is forced through it.

Exercise 2.

1. **Object:** To show that apples take up oxygen from the air.
2. **Method:**
   a. In a large basin partially filled with water set a small support on which is placed an apple and a small open dish containing a solution of caustic soda or potash.
   b. The apple should not touch the water or the caustic solution.
   c. Cover the support and its contents by a large bell glass or wide jar with its mouth wholly in the water.
   d. Now as the apple breathes in the oxygen in the air, and breathes out carbonic acid gas, the latter will be absorbed by the caustic solution, while the water will rise in the jar to fill the space made vacant by the removal of the oxygen.
   e. Finally the water will fill about one-fifth of the air space originally present, and remain stationary because the oxygen is all used.

STORAGE OF FRUIT.

1. **Requirements.**
   a. **Quality of fruit.**
      1. It does not pay to store anything but first grade fruit.
      2. Shrinkage and loss are not checked but retarded in storage.
   b. **Handling of fruit.**

1. Careful picking, sorting and packing.
2. Subsequent handling after storing.
3. Wrapping in paper serves to reduce the bruising from poor packing and in transportation.

2. **Delaying storage.**
   a. Causes deterioration of large quantities of fruit.
   b. Extent of the loss depends on:
      1. Temperature during delay.
      2. Whether put in piles in orchard or in tight building where the warm air can pass off readily.
      3. Fungus diseases readily start while fruit is warm and can not be checked when put in cold storage.
   c. Any treatment that checks the ripening after picking prolongs the marketing period.

3. **Problems of storage.**
   a. The ability to hold part of the crop until the perishable surplus has been disposed of, means higher prices, easier sales, and better accommodations.
   b. Storage system will check over-stocking the market.
   c. The economical problem is not to secure high prices for small quantity, but an average price for large quantity.
   d. **Essential points.**
      1. What varieties are best suited for storage?
      2. What conditions must be provided to secure the best and most economical management of stored fruit?
      3. Some varieties in storage vary in behavior, scalding, shrinking, losing flavor, becoming dull colored and unattractive.
      4. Other varieties come out of storage smooth, bright, fragrant and crisp.
      5. Early ripening varieties are held one or two degrees higher, but may be held at lower temperature for longer time, but decay very rapidly when taken from storage.

4. **Handling the fruit in storage.**
   a. Placing on shelves.
   b. Placing in shallow bins.
   c. Amount put in room at one time.
   d. Method now used is to store fruit in packages.
   e. The amount of fresh, warm fruit put into a storage room at once should not be excessive
   f. It is better to fill a room slowly and allow time for each lot to cool.

5. **Temperature.**
   a. Temperature varies from 32° to 34° F. for apples.
   b. Long keeping varieties that go down slowly are held at a lower temperature than 32° F.
   c. Early ripening varieties that go down quickly are held one or two degrees higher.
   d. Some fruit cannot be held as low as 32° since it freezes at a higher temperature.
   e. Very large fruit does not keep as well as smaller fruit of the same variety.

f. **Approximate temperature:**

Name.	Summer	Winter	General
Apples	36-42	32-35	.....
Pears	36-44	33-38	.....
Peaches	.....	.....	36-38
Plums	.....	.....	36-42
Cherries	.....	.....	38-40
Grapes	.....	.....	32-36
Strawberries	.....	.....	36-44
Potatoes	.....	.....	36-40
Onions	.....	.....	34-38
Cabbage	.....	.....	34-36
Turnips	.....	.....	34-40

6. **Influence of cold storage on the decay of apples.**
   a. **Chemical changes** in apples during storage.
      1. The apple is a living organism when picked from the tree and remains so after picking for days, weeks, and even months, under favorable conditions.
      2. This life is maintained at the expense of its own constituents, and the apple is really undergoing a slow form of dissolution until decay attacks and destroys it, leaving only the fibrous portions of its structure and the seeds.
      3. The process of dissolution is a continuous one, and is manifested by the respiratory action, during which water and carbon dioxide are exhaled.
      4. At the same time there are transformation and destruction of the constituents of the fruit, in order to produce these products of respiration.
      5. These changes have been shown to be mainly a transformation of starch into sugar cane in the first stage after picking, next change of the cane sugar into invert sugar, and finally a slow decrease in the total quantity of sugars.
      6. At the same time, the acid in the fruit gradually grows less in amount, there being most in the unripe fruit.
   b. **Storage in cellars.**
      1. One of the chief sources of trouble arises from an imperfect understanding of the principles involved in keeping fruit and in the management of the cellar.
      2. The prevalent notion was that the cellar is for the purpose of keeping cold air out and to protect the contents of the cellar against freezing.
      3. The conditions are to keep cold air in, and by careful attention to the ventilation during cool weather and of nights to cool the interior of the cellar and its contents and maintain as far as possible a uniformity in the inside temperature.
      4. This uniformity has more to do with keeping apples successfully than the actual temperature itself.
      5. Once chilled, any subsequent rise in temperature causes the fruit to sweat from the deposit of moisture from the air on the cool surface of the fruit, hence a rise in temperature is more to be guarded against than the contrary.

6. In ordinary storage it is almost impossible to maintain wholly uniform temperature, the thing then to do is to avoid sudden changes.
7. A cool air, free from excessive dampness, uniform temperature, and darkness, are the conditions favorable to the keeping of fruit in ordinary storage.
8. A well insulated door and a well insulated vestibule entrance to the cellar make it much easier to prevent sudden changes and contributes to prolong the period through which fruit may be kept in sound condition.
9. It is desirable also to enter the cellar as little as possible except when the outside temperature is lower than the within.
10. Apples which are allowed to mellow on the tree or after they are gathered, have their life period greatly shortened.
11. The ideal stage is when the fruit is full grown, but some days before it would begin to show signs of mellowness.
12. Other points to be observed formerly are the selections of late maturing, good keeping varieties, and gathering the fruit in cold weather or late in the day when it can stand open all night to become chilled before going into the cellar.
13. The location of the cellar on a slope or hillside to the north, with openings up and down the hill, favors thorough ventilation during the cool nights.
14. By opening the cellar early in the night in cold weather and closing the doors before sunrise, the cellar is cooled and the cool air is kept caged in.
15. The essential idea is in keeping the cool air in rather than keeping out the warm air, or protection against freezing and maintaining as equable temperature as possible by careful attention to ventilation.
16. Fruit does not keep in cold storage satisfactorily unless it is carefully and properly handled by the grower before sending it to the storage room.

c. **Systems of storage.**

1. **Mechanical refrigeration.**
   a. The expense of installing and maintaining a plant places mechanical refrigeration out of reach of the fruit grower and makes it a business by itself.
   b. The mechanical refrigeration furnishes the ideal cold storage, gives the best control of temperature and results.
   c. The mechanical refrigeration is cooled by machinery and costs less when large quantities are handled.
   d. Fruit grower can rent space in mechanical refrigeration at less expense than to have a plant.
   e. What the grower cares to know is "Is this method of storage successful?" and "What does it cost?"
2. **Ice refrigeration.**
   a. The use of ice for cooling a fruit storage room is often practicable on farms.
   b. The difficulty is that the ice has to be carried all summer as it is needed in late fall.

c. The usual method is to build an ice refrigeration plant.
   1. Place the ice above the storage room.
   2. The cool air should flow from the ice room into the fruit room and the warm air carried off through flues or shafts.
   3. The cool air is best allowed to flow down at the sides of the building behind guides, which bring it near to the floor, in which case the warm air exit is placed in the center of the room and opens near the ceiling.
   4. The compartments consist of a refrigerator room, a cooling room, and a small entrance room.
   5. The floor should be laid tight, and provided with good drainage.
   6. Another method is to arrange around the sides of the storage room a series of vertical pipes, which are set in wooden troughs and terminate in a board trough in the ice chamber above.

3. **Cooling by ventilation.**
   a. The most economical method of storage for the farm use and for ordinary fruit growers is one that depends on ventilation for the regulation of the temperature.
   b. The requirements.
      1. Thorough insulation against outside changes of temperature.
      2. Adequate ventilation.
      3. Careful and constant attention when fruit is put in and before.
      4. Protection from frost.
      5. Air moist enough to prevent evaporation.

4. **Building a storage house.**
   a. Use 2x4 studdings.
   b. The outside wall.
      1. Layer of 1-inch board.
      2. Layer of building paper.
      3. Finished with well matched siding.
   c. The inside wall.
      1. Layer of 1-inch board.
      2. Two layers of building paper.
      3. Layer of well matched ceiling.
      4. Heavily painted.
   d. The ventilating system consists of an intake for cold air and an outlet for warm air.
   e. The intake should be beneath the floor and the cold air brought up through the registers.
   f. The warm air exit must be placed in the upper part of the room.
   g. Study plans of a good storage house.
   h. Make a drawing of a good storage house.
   i. Make out the specifications of a good storage house.
   j. Figure out the cost of a good storage house.

7. **Questions.**
   a. What effect have soils on the color and ripening of fruits?

b. What effect has dry weather on keeping?
c. What effect has wet weather on keeping?
d. What kind of fruit should be stored?
e. What influence has color on the keeping of fruit?

FRUIT MARKET.

1. It is important that the fruit market and its requirements are known by those who expect to grow fruit for sale.
2. If one knows where the fruit is going and what is to be expected, better preparation can be made to meet the needs of the consumer.
3. **Two markets.**
   a. First—the wholesale, general or indirect market.
   b. Second—the retail, special or direct market.
   c. Quantity.
      1. The first handles fruit in large quantities.
      2. The second handles fruit in small quantities.
   d. Market problems.
      1. **Growing fruit.**
         a. The proper kind and quality must be the first requisite.
         b. The grower must know how to grow the best quality of fruit.
         c. The grower must know when to harvest the different crops of fruit, in order to put them on the market in the best condition.
         d. The grower must know how to grow the crops at the least expense.
      2. **Preparing the fruit for market.**
         a. See picking, grading, packing and storage.
         b. The grower must know how to prepare different kinds of fruit for market in order to bring the best prices.
      3. **Transportation.**
         a. No other one condition has more to do to determine the kind of fruit, localization and profit, than transportation.
         b. Facilities and rates are of great importance.
      4. **Different ways of selling.**
         a. **Individual market.**
            1. Each grower may look up his market some weeks in advance of the market season.
            2. The grower may definitely arrange with the different local dealers to sell a certain amount of fruit, then the dealers can inform their customers and find a sale for the given amount.
            3. Individual markets are an annual enterprise which must be renewed each year.
         b. **Commission men.**
            1. Explain how commission men handle fruit for the grower.
            2. The grower must produce first-class fruits uniformly and honestly graded and packed and delivered to the commission men in sound and attractive condition.
            3. The commission man should find the best market and make honest returns to the grower.

4. Suggestive points.
   a. Stick to one man.
   b. Ship the same varieties.
   c. Grade and pack with the most rigid honesty.
   d. Follow the advice of the commission man in preparing fruit for market.

c. The relation between the fruit grower and commission man has created two ways of retreat for the fruit grower.
   1. Individual markets.
   2. Co-operative markets or associations.

d. Favorable points for an association.
   1. Better distribution of the fruit.
   2. Special salesmen to handle the fruit.
   3. **Economy.**
      a. Better storage for fruit.
      b. Better and cheaper labor.
      c. Selling supplies to growers.
   4. Transportation.
   5. Better and more uniform grading and packing.
   6. Command of markets.
   7. Restriction of outputs.

e. Unfavorable points for associations.
   1. Distrust of the grower.
   2. Grower wants to pay low wages to managers.
   3. Irregularity in grading the different grower's fruit.

f. Conditions affecting market supply.
   1. Production; whether over-production or shortage.
   2. Transportation facilities.
   3. Information concerning markets.
   4. Perishability of the fruit.
   5. Storage equalizes the supply.
   6. Quantity determines the sale.
   7. Acquaintance of the quality of fruit.
   8. Price depends on the supply and demand.
   9. Demands for certain fruit out of season.
   10. Supply of other fruits.

4. **References.**
   a. Fruit Growing, by Bailey.
   b. Fruit Harvesting, Storing and Marketing, by Waugh.
   c. Fruit Growing, by Paddock and Whipple.
   d. Iowa Bulletin No. 108.
   e. Arkansas Circular No. 13.
   f. N. H. Bulletin No. 93.
   g. N. Y. Bulletins Nos. 248, 297.

GEOGRAPHY OF FRUIT GROWING.

1. **Relief form.**
   a. Low lands.
      1. Plains.
      2. Valleys.
   b. High lands.
      1. Plateaus.
      2. Mountains.

Location.
   c. Water.
      1. Oceans.
      2. Lakes.
      3. Rivers.

2. **Fruit zones.**
   a. Temperature—typified by Pome fruit.
   b. Semi-tropical—typified by citrous fruit.
   c. Tropical—typified by tropical fruit.
   d. Draw a map and locate each zone.
   e. Relative annual temperature.
      1. Depends on latitude, altitude, and bodies of water.
3. **Climate.**
   a. Modification.
      1. Distribution of land and water.
      2. Elevation.
      3. Slopes.
      4. Mountains.
      5. Nature of surface.
      6. Prevailing winds.
      7. Bodies of water.
      8. Latitude.
      9. Moisture.
         a. Isotherms—lines of equal temperature.
         b. Isohyetoses—lines of equal rainfall.
            1. Pacific coast zone.
            2. Atlantic coast zone.
            3. Plain zone.
            4. Arid zone.
      10. Winds and air currents.
         a. Name of wind zones.
         b. Breezes.
            1. Land and sea breezes.
            2. Canyon breezes.
         c. Mountain winds.
         d. Local winds.
         e. Study local air drainage.
4. **Accessibility.**
   a. Railroads.
   b. Communication.
   c. Transportation.
   d. Wagon roads.
   e. Markets.
      1. Facilities.
      2. Consumption.

SITES.

1. The site should be elevated above its immediate surroundings.
2. An elevated site will afford better soil drainage.
3. An elevated site will afford better air drainage.
4. **Slopes.**
   a. The most intelligent and experienced orchardists differ as to the best location and exposure of an orchard, some preferring a northern slope, others an eastern slope.
   b. It is believed that the advantages preponderate in favor of a gentle eastern or northeastern slope, as orchards located on such a site suffer less from the effects of heat, drought, and poor soil.

c. An orchard with such an exposure will maintain its vigor and longevity better than if inclined to the west or southwest.
d. All farms do not afford these most favorable sites, especially near the home, which is the most desirable location for the family orchard.
e. The planter will often be forced to forego such a location and take his chances where the natural conditions are not so favorable.

5. **A free circulation** of air will be a great aid in guarding against late spring frosts, so fatal to young fruit at the blooming season.
6. **References:**
   a. Fruit Growing by Bailey.
   b. Fruit Growing by Paddock and Whipple.
   c. Farm and Garden Rule-Book, by Bailey.
   d. Popular Fruit Growing by Green.

KIND OF SOILS.

1. **Loamy soil.**
   a. A loamy soil is naturally rich in plant food; hence it will need little, if any, manuring in its preparation.
   b. It should be deeply stirred and thoroughly broken up by subsoiling.
   c. This loamy soil is what may be termed free soil, as it seldom becomes compacted, even by abusive treatment.
2. **Clay soil.**
   a. A clay soil is the most difficult to prepare, and often requires manuring, as well as thorough plowing, re-plowing and subsoiling.
   b. It should also be frequently stirred during the summer months and especially as soon after each rainfall as is practicable, to prevent it from baking and becoming compacted.
   c. This becomes even more important in seasons of long droughts.
3. **Sandy soils.**
   a. Sandy soils are generally lacking in the necessary plant food.
   b. They also have the objection of losing such fertilizers as may be added by the several crops.
4. **Effects of several soils.**
   a. The wood growth on loamy soils will be strong and vigorous, but may not be sufficiently mature to withstand the freezing of the more vigorous winters.
   b. Clay lands not apt to produce such vigorous growth, and orchard trees on such lands will be hardier as to winter-killing than on most other soils.
   c. With a free subsoil underlying it, a loamy clay soil will probably yield the best results, especially if it be well prepared by thorough cultivation and subsoiling before the trees are planted.
   d. Timber lands, or lands on which forests have grown, if having the proper exposure and drainage, are good orchard sites.
   e. Such lands contain all the elements of plant food necessary to insure a good and sufficient wood growth and fruitfulness.
   f. Sandy soil is well adapted for fruit if it can be irrigated or is located where the water-table is within the reach of the roots of the trees.

THE TILLING OF FRUIT LANDS.

1. **Object.**
   a. To improve the physical texture of the soil.
   b. To conserve the moisture of the soil.
   c. To give light, air and soil to plants by destroying the weeds.
   d. To protect from drought by keeping the top soil loose.
      1. To prevent evaporation.
      2. To increase capillary attraction.
      3. To hold moisture from subsoil near the surface.
   e. To set plant food free.
      1. Unlock the organic and inorganic elements.
2. **Kind of tools.**
   a. Name and describe the different tools.
   b. Use of the various tools.
   c. Cultivators and rollers.
3. **Mulching.**
   a. Kind.
   b. Protect the trees or plants.
   c. Conservation of moisture.
   d. May harbor insects.
4. **Preparation.**
   a. The principal requirement in preparing land for planting an orchard is deep tillage, and the more thoroughly this work is done the more certain is the success.
   b. The preparation had best be done late in the fall, so that the land will be ready for early spring planting or for fall planting.
   c. Many successful orchardists, especially in the Western States, plow the ground in "lands" so as to make an open furrow where each row of trees is to be set, and then after the trees are planted back-furrow the ground so as to make lands with tree rows in the center.
5. **Suggestions for tilling fruit lands.**
   a. Begin to till when the orchard is planted and keep it up.
   b. Begin tillage early in the season because of the growth of the trees early in the season.
   c. Tillage should generally be stopped by August 15th.
   d. Keep the land in a uniform fine tilth.
   e. If the tree growth is too rapid, tilling should be stopped.
   f. It is from capillary water that agricultural plants, for the most part, obtain the water necessary for their growth.
   g. There should be no large spaces since these cause the soil to dry out readily and

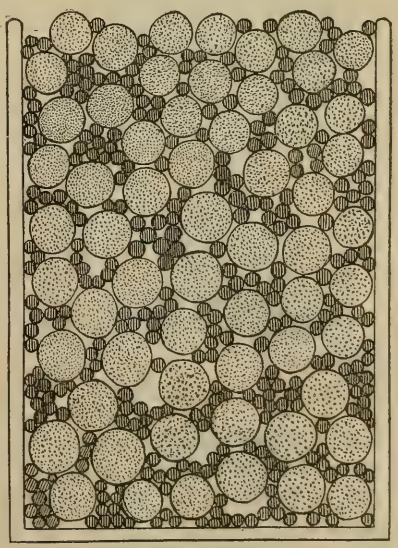


Fig. 23.—Shows spaces between particles. (Goff and Maynes.)

prevent the development of the many fine branching rootlets necessary to the best development of th plants.

h. Mechanical condition of the soil must be porous but not loose; firm, but not hard or consolidated; close-grained, but not run together nor adhesive.

i. Pulverizing breaks the soil into granules which are free to move under capillary force and yet it does not exclude the air, nor interfere with any of the vital, chemical or physical processes in the soil, but is conducive to them.

6. **Effect of tillage.**

a. Fining the soil and presenting greater feeding surface to the roots.

b. The roots will have a greater foraging and holding area.

c. The soil is made warmer and dryer in the spring.

d. The temperature and moisture are more uniform.

e. Checks evaporation.

f. Increases the water-holding capacity.

g. Promotes chemical action and nitrification.

h. Hastening decomposition of organic matter.

i. The soil should be brought into the desirable condition already described, so that there will be a deep, mellow, but firm seed and root bed to absorb and store the rainfall and to prepare plant food.

j. Plowing is the most important of the operations in preparing the seed bed.

7. **References.** a. See references under sites.

DRAINAGE.

1. All orchard lands should be thoroughly surface-drained and underdrained.

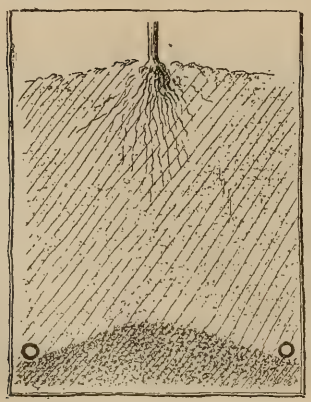


Fig. 24.—On well-drained soils the roots strike downward.

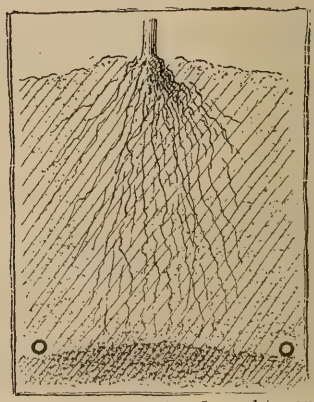


Fig. 25.—When the drought comes the plants do not suffer.

(Principles of Agriculture, by Bailey.)

2. No orchard can endure for a great length of time with stagnant water either on the surface or within the soil.

3. All surplus water from excessive rainfall or from other causes should be promptly removed by either surface or sub-drainage.

4. If the natural formation of the land does not afford such prompt drainage it must be provided artificially.

5. **Need of air in the soil.**
   a. There are flat lands and heavy clays where a system of tile drains is of more value than other treatment that can be given them.
   b. Such soils hold water within them in a form that has been designated as free water, or gravitational water.
   c. There are several disadvantages or injurious consequences resulting from having a soil so filled with water.
   d. The oxygen of the air is necessary in soils for the direct use of plants.
   e. Their roots can not grow and extend into the soils to find water and food constituents except in the presence of oxygen.
   f. Seeds can not germinate in the absence of oxygen.
   g. Microscopic organisms, which are so essential in properly maintaining the fertility of soils, require oxygen just as much as higher organisms do.
   h. The decay of organic matter in the soil in the presence of oxygen is of such character that its products are usually favorable to plant growth.
   i. Nitrates, generally the most important elements of plant food, are produced in the presence of free oxygen only.

6. **Disadvantages of wet soils.**

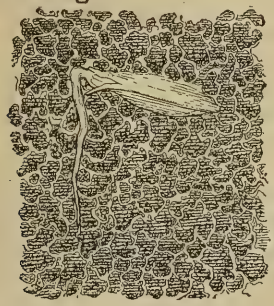


Fig. 26.—A well-drained but moist soil.

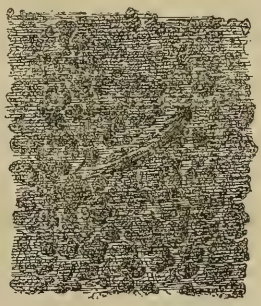


Fig. 27.—A wet, uncongenial soil.

(Principles of Agriculture.—By Bailey.)

   a. The entrance of this essential oxygen of the air into soils is hindered when the pores of the soil are filled with water.

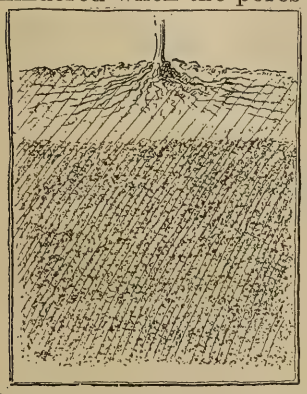


Fig. 28.—Showing the condition in spring on cold, undrained soils, when the water-table is too high.

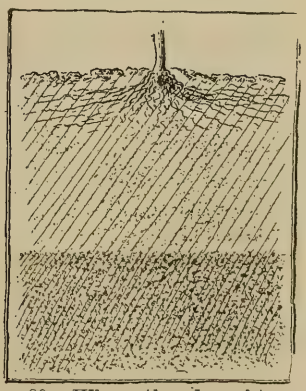


Fig. 29.—When the drought comes the plant is still shallow-rooted and it suffers.

(Principles of Agriculture.—By Bailey.)

b. Wet soils are cold, because the water as well as the soil must be heated and water warms up much more slowly than soil.
c. The removal of the excess of water by drainage permits the heat of the sun to warm the soils earlier to a proper degree for the germination of seeds.
d. Clay soils, when too wet, run together and become plastic, and with difficulty, are permeated by water, air, and the roots of plants.
e. If they be plowed when too wet, they become still more puddled, and it requires protracted weathering to bring them into fair condition again.

7. **Depth of drains.**
   a. Generally the deeper the tiles are placed, the more effective and perfect the drainage, and also the more expensive.
   b. Drains should be laid below the frost line and out of the way of all tillage operations.
   c. They should be laid by the use of a level, so that there may be no sags or traps in the drain, and the outlets should be such that the water runs freely from the tile.
   d. The depth varies from 2½ to 4 feet deep.
   e. The depth depends on the subsoil.
   f. The ground-water surface should not be below the limit that the water can be lifted by capillarity.
8. **Distance between drains depends on:**
   a. The freedom with which water may flow through the subsoil toward the drains.
   b. The depth at which the drains are placed.
   c. The interval of time between rainfalls.
9. **Kind of drains.**
   a. Surface ditches or furrows between the rows of trees may afford temporary drainage, but they are objectionable on other accounts that will be apparent; for an orchard thus drained will be difficult to get over in its necessary care and in gathering and handling the fruit.
   b. Under-drainage is far better on these accounts; besides it is much more thorough, especially if accomplished by means of well laid tile.
   c. A thorough breaking up of the subsoil will afford temporary drainage in a stiff clay soil, but in a few years the soil may again become compacted, when it will require re-stirring.
   d. But in all cases the planter must be the judge of the special drainage requirements of his soil and location.
10. **How water enters tile drains.**
    a. Through the walls and joints of the tile.
    b. The length of the tile should be short.
11. **The size of tile.**
    a. Six-inch tile generally gives better satisfaction than smaller tile.
    b. There are less chance for six-inch tile to become clogged with roots and silt than smaller tile.
12. **References.**
    a. See references under sites.
    b. Soils, Vol. I, by Brooks.

c. Irrigation and Drainage by King.

WINDBREAKS.

1. **Position of windbreaks.**
2. **How to make windbreaks.**
3. **Benefits.**
   a. Protection from cold.
   b. Reduces evaporation.
   c. Lessens windfalls.
   d. Lessens damage to trees.
   e. Retains snow and leaves.
   f. Facilitates labor.
   g. Protects blossoms.
   h. Makes straighter trees.
   i. Lessens the drying of fruit.
   j. Lessens the maturity of fruit.
   k. More birds.
4. **Injurious.**
   a. May be colder.
   b. Increases insects and diseases.
      1. Check by spraying.
   c. Trees less thrifty.
   d. Damage from late spring frosts.
5. **Kind of trees.**
6. **References.**
   a. Fruit Growing by Bailey.
   b. Fruit Growing by Poddock and Whipple.
   c. Colorado Bulletin No. 35.
   d. North Dakota Bulletin No. 88.
   e. Iowa Extension Bulletin No. 5.
   f. Nevada Bulletin No. 79.

SOIL FERTILITY.

1. It is fully realized that all soils are not of the same producing value and we are to determine in a large measure the causes which go to make towards fertility and also those causes which tend to make a soil sterile.
2. **Comparison of soils.**
   a. Two soils may give practically the same mechanical analysis, and one may be a good soil, while the other may be a very poor soil.
   b. Two soils may give practically the same chemical analysis, and one may be productive, while the other may not.
   c. Two soils may contain practically the same content of plant food elements and may be very far apart in agricultural value.
   d. Agricultural value.
      1. This is due to the fact that plant food exists as soluble matter in the soil water.
      2. The water capacity of the sandy soil is less than the silty or clayey.
      3. Under the same conditions, if a plant begins to suffer for water when the clayey soil has its water contents reduced to 12%, the plant will not suffer in silty soil until the water contents are reduced to 8% and in sandy soil from 6 to 4%.
      4. Hence the soluble plant food is more concentrated in sand than in the others.
      5. For this reason the chemical analysis may show less total plant food in the sandy than in the clay, yet the former may produce better crops.
3. The capacity of a soil to grow crops does not depend upon the quantities of food compounds present but upon the quantities of them which are available to the plants in liquid form.

4. Plant food made available in liquid form by
   a. Oxidation caused by warm moisture and air, as rust.
      1. Plowing, cultivation, and irrigation may loosen, pulverize and aerate the soil causing oxidation.
   b. Solution caused by bacteria producing acid of decay.
      1. Addition of humus or organic matter aids the bacteria in producing the acid of decay.
5. Soil may be made more fertile by—
   a. **Green manuring.**
      1. Green manuring, or the plowing under of crops, is one of the oldest methods used to maintain or to increase the productivity of the soil.
      2. The effect of green manuring varies according to the original character of the soil.
      3. In general, sandy or gravelly soils are made darker in color and become more retentive of moisture.
      4. Clayey soils are made more porous and friable, so that they are less likely to puddle or bake, and are less subject to washing.
      5. The most important object achieved by green manuring is the addition of humus to the soil.
      6. Deep-rooted plants are decidedly preferable to shallow-rooted ones because they penetrate into the subsoil.
      7. In this way, air and water find entrance, especially after the roots decay.
      8. It is also supposed that such plants, especially when plowed under, tend to enrich the surface soil with potash and phosphorus from the subsoil, thus bringing these substances within reach of the shallow-rooted plants.
      9. See Cover crops.
   b. **Barnyard manure.**
      1. Barnyard manure is the most important manurial resource of the farm and should be carefully saved and used.
      2. It represents fertility which is drawn from the soil and must be returned to it if productiveness is to be maintained.
      3. It not only enriches the soil with nitrogen, phosphoric acid and potash, but it also renders the stored-up materials of the soil more available; improves the mechanical condition of the soil, makes it warmer, and enables it to retain more moisture.
      4. The amounts of fertilizing constituents in the manure stand in direct relation to those in the food.
         a. As regards the value of manure produced, the concentrated feeding stuffs, such as meat scraps, cotton-seed meal, linseed meal and wheat bran, stand first; the leguminous plants (clover, peas, etc.) second; the grasses, third; cereals (oats, corn, etc.), fourth; and root crops, such as turnips, beets and mangel wurzels, last.
      5. The nitrogen of the food exerts a greater influence on the quality of the manure than any other constituent.
      6. It undergoes more modification in the animal stomach than the mineral constituents (potash and phosphoric acid), and rapidly escapes from the manure in fermentation.

7. The deterioration of manure results from two chief causes.
   a. Fermentation, whereby nitrogen, either as ammonia or in the gaseous state, is set free.
   b. Weathering or leaching, which involves a loss of the soluble fertilizing constituents.
8. The loss from destructive fermentation may be largely prevented by the use of proper absorbents and by keeping the manure moist and compact.
9. Loss from leaching may be prevented by storage under cover or in water-tight pits.
10. The disposition to be made of the manure of the farm (both fermented and unfermented) must be determined largely by the nature of the crop and soil.
11. Where improvement of the mechanical condition of the soil is the principal object sought, fresh manure is best adapted for this purpose to heavy soils and well-rotted manure to light soils. It is not advisable to let manure rot even for the latter soil; it ought to be used fresh.
12. It not only supplies humus, but it contains a large per cent of other necessary nutritive elements for maintaining health, vigor and fruitfulness of tree and for the developemnt of the proper qualities for fine fruit.

c. **Commercial Fertilizers.**

1. **Nitrogen.**
   a. Sources.
      1. Animals, dried blood, tankage, fish offal, meat scraps, flesh and meal.
      2. Vegetation.
         a. Cotton seed meal.
         b. Leguminous crops, as clover and peas.
   b. Use of nitrogen.
      1. Organic nitrogen exists in combination with other elements, either as vegetable or animal matter.
      2. All materials containing nitrogen are valuable in proportion to the rapidity of decay or change.
      3. Organic nitrogen differs in availability, not only according to the kind of material which supplies it, but according to the treatment it receives.
      4. Gradual change makes nitrogenous manures valuable in light, open soils, from which the nitrate or ammonia nitrogen tends to disappear too quickly.
      5. The amount of available phosphoric acid, potash and lime is determined by the decay of the nitrogenous organic matter.
      6. Nitrogen is essential to vigorous growth, and oversupply promotes rank growth of twigs and foliage.
      7. Nitrogen gives a full, dark green color to the foliage.
      8. Nitrogen gives a splendid leaf and wood growth.
      9. Nitrogen used in excess produces too much wood and less fruit.

2. **Potash.**
   a. Sources.

1. Wood ashes.
2. Stassfurt salts.
3. Kainite.
4. Muriate of potash.
5. Sulphate of potash.

b. Uses of potash.
1. It is important in fruit growing.
   a. It aids in developing buds and leaves.
   b. It aids in developing color.
   c. It is the base in combination with fruit acids.
   d. It adds ash to the fruit.
2. Its presence is necessary for the formation of starch and sugar, although it does not enter into their composition.
3. It gives firmness and aids in maturing and ripening the wood.

3. **Phosphates.**
a. Sources.
1. Phosphoric rocks.
2. Phosphate slug.
3. Bone.
4. Guano.

b. Use of phosphate.
1. Phosphoric acid is derived from materials called phosphates in which it may exist in combination with lime, iron or alumina.
2. Phosphate of lime is the form most largely used as a phosphoric acid.
3. Phosphoric acid occurs in fertilizers, as:
   a. That soluble in water, and readily taken up by plants.
   b. That slightly soluble in water, but still readily used by plants, also known as "reverted."
   c. That very sparingly soluble in water, and consequently very slowly used by the plant.
   d. The gases and organic acids produced in the decay of vegetable substance greatly increases its solubility and causes phosphates to serve as a source of available plant food.
4. It is important in the developing of seeds.
5. It adds to the perfect ripening of the fruit.
6. It is an essential constituent of tree and fruit.
7. It will correct the too great a growth caused by the excess of nitrogen, turning the excessive growth into flowers and fruit.

4. **Lime.**
a. Sources.
1. Limestone.
2. Chalk.
3. Shells.
4. Marl.

b. Use of lime.
   1. It aids in producing hard, firm wood.
   2. It aids the tree to mature and to go into the dormant state.
   3. It liberates plant food.
   4. It liberates potassium.

5. Signs of need for fertilizers.
   a. See nitrogen, potash, phosphate.
   b. When the growth of the terminal branches fails to make an annual growth of at least one foot, the tree should be stimulated by manuring the land and giving it a thorough cultivation.
   c. Study the tubercles of the leguminous plants in the field that gives poor results.
6. Orchards that are well tilled, well drained and properly supplied with organic matter from stable manure or cover crops need very little commercial fertilizers.
7. If trees are not vigorous, bearing well, and making fair growth each year, the thing to do is to look to the drainage, tillage and health of the trees first.
8. **References.**
   a. Fruit Growing by Bailey.
   b. Fruit Growing by Paddock and Whipple.
   c. U. S. Dept. Bulletins Nos. 77, 121, 192, 271, 278.
   d. Wisconsin Bulletin No. 82.
   e. Maryland Bulletin No. 144.
   f. Soils and Fertilizers by Snyder.

IRRIGATION.

1. **Physical properties.**
   a. Climatic conditions.
   b. Character and depth of soil.
      1. Examination should be made.
         a. The character and depth of the soil.
         b. Its behavior when irrigated.
         c. The slope and evenness of the surfaces.
         d. The presence of injurious salts.
         e. The facilities for drainage.
   c. The top layer of the soil.
      1. Protects the moist soil beneath, which furnishes both food and water to the fibrous roots.
      2. The presence of any hard, impervious stratum is objectionable.
      3. A porous stratum of coarse gravel may waste large quantities of irrigation water.
      4. The subsoil is determined by boring holes to a depth of 10 feet, and taking samples of soil at different depths.
2. **Proper percentage of soil moisture.**
   a. Too little, as well as too much moisture in soils, injures plants and it is not easy to find out how much is best for each kind of soil and for each kind of crop.
   b. About three-fifths of the volume of clay soils and two-fifths of sandy soils are open spaces, while the loams range between.

c. The greater part of the water found in the open spaces furnishes moisture to the roots of plants; the remainder clings to the soil particles and requires a considerable amount of heat to drive it off in the form of vapor.
d. Moisture is not the only essential.
1. In attempting to find out how much free moisture cropped soils should contain, it is well to bear in mind the fact that while moisture is the principal element in growing crops on arid lands, it is not the only essential.
2. Temperature, winds, sunshine, fogs, disease and a lack of air in the soil very frequently affect crops.
3. When a crop is suffering, an effort should be made to discover the cause and not jump to the conclusion that more water is needed.

3. **Movement of water in soils.**
a. The greater part of the water that falls as rain passes into the soil.
b. The water which does enter the soil passes downward, as free or gravitational water which forms visible liquid layers on the soil grains or occurs between them being pulled down by gravity.
c. The water held by the soil particles against the force of gravity is called capillary water.
d. It can not be seen as liquid water, but its presence may be recognized by its effect upon the color of the soil.
e. If in too great quantity to be disposed of by capillarity, the rain water runs down into the lower soil and finally joins the so-called gravitational water, raising its level temporarily.
f. In dry weather the capillary water evaporates from the surface of the soil; the soil draws more water from below, but not in sufficient quantity wholly to replace that lost by evaporation.
g. There is a continual decrease in the content of capillary water until another rainfall.
h. The free or gravitational water may rise into the soil as capillary water to replace that lost by evaporation.
i. It is constantly running out of the soil into the natural drainage channels as spring and seepage waters.
j. These several motions of water all take place when the rainfalls are sufficient to give an excess over what the soil can hold in what has been called the capillary state.
k. If the surface soil be open and loose, heavy rains completely fill the spaces of the upper soil.
1. When the pulverized layer is thin, it often becomes so soft and filled with water that this loose layer washes and greatly injures a field.

4. **Time to irrigate.**
a. Tests for moisture.
1. Healthy, vigorous growth of stems, branches and foliage of light green color are an indication of moisture.
2. Do not wait to irrigate until the leaves turn to dark, dull shade of green and begin to curl.
3. Find out where the feeding roots are located; nature of soil around them; test the soil from 6 to 12 inches beneath the

surface by compressing it in the hand; if it falls apart, it is too dry.

EXERCISE 3.

1. **Object:** To test for capillary water in the soil.
2. **Method:**
   a. Take a sample of soil from around the roots of the tree about 2 feet.
   b. Place sample of soil in a glass fruit jar and screw on the cover tightly on a rubber band.
   c. Weigh sample before drying.
   d. Dry the sample in sun or drying oven.
   e. Weigh sample after it is dried.
   f. Divide the loss in weight by the weight of moist soil to get the per cent of free water.
   g. The moisture should range between 5 to 10 per cent in orchard loams.

5. **The number of irrigations depends on:**
   a. Depth and nature of soil; amount of rainfall; temperature; wind.
   b. When the rainfall is less than 20 inches, irrigation is a great help with such fruit; as, the apple.
   c. Three irrigations during the growing season are ample under most conditions if followed by intensive cultivation.
   d. Irrigation usually begins about the last of April or early in May and at intervals of 20 to 30 days.
   e. Light irrigation may be given the last of August to produce: Good crop of fruit; prevent heavy dropping; give more color to fruit.
   f. Do not use large amount of water near the time of picking as it tends to keep the trees in active growth and may have a bad effect on the fruit; as, peaches.
   g. It is poor practice to irrigate peaches within three weeks of picking time.
   h. Heavy irrigation with young orchards may increase winter-killing and is sure to retard root development, hence growth.
   i. There must be good drainage.
   j. Irrigation at intervals of thirty to forty-five days during the irrigation season will provide ample moisture for ordinary loamy soils.
   k. Young trees are watered by a furrow on each side of the row, and as the trees grow older and larger the number of furrows is increased until all the space between the rows is watered.
   l. It is better to make the irrigation ditch in the tree row in alkali soil as there will be more alkali between the furrows than in the irrigating furrows.
   m. The idea to be kept in mind is to train the roots outward and downward so as to enlarge their feeding zone.
   n. The less a young tree is irrigated and yet kept in a rapid growing condition the greater the development of the root system.
   o. The best guide to successful practice is to make frequent excavations to find out not only the location of the roots, but also how far and in which direction the water from the furrows has percolated.

6. **Cultivation after irrigation.**
   a. When the tract is planted with the right kind of stock the next most important thing is frequent and thorough cultivation.
   b. The surface should be cultivated after each rain and after each irrigation, and occasionally in the intervals.
   c. The proper depth to cultivate will depend on a variety of conditions, but it is well to bear in mind that if anything like complete protection from soil evaporation is desired, the cultivator teeth should be lowered to eight inches beneath the surface.
   d. **Objects:**
      1. To maintain a sufficient supply of moisture.
      2. To make available plant food.
      3. To pulverize the soil making a greater fooding area for the rootlets of the trees.
      4. To give an additional root-holding area for the plants.
      5. To promote nitrification.
      6. To hasten decomposition of humus and organic matter.
      7. To form a mulch to prevent evaporation.
7. **References:**
   a. Fruit Growing by Bailey.
   b. Fruit Growing by Paddock and Whipple.
   c. U. S. Bulletins Nos. 116, 404, 158, 263.
   d. Oregon Bulletin No. 111.
   e. Irrigation and Drainage by King.

GROWTH OF FRUIT TREES
Compared With Other Crops.

1. **First comparison.**
   a. Trees have a preparatory time of several years before fruit bearing begins.
   b. Trees have several "off years" during their life.
   c. Farm crops make their growth, bear crop and pass away in a single season.
   d. **Essential factors for both.**
      1. **Temperature.**
         a. It is sufficient to say that the climate of a section of a country, with regard to temperature, fixes within limits, the kind of crops which can be grown with success.
      2. **Moisture.**
         a. Water is a very important factor in crop production.
         b. The size of the crop decreases if the amount of water is lessened, or increased beyond a certain point, that is to say, if the soil is kept too wet or too dry.
         c. A clay soil requires more moisture than a sandy soil, but at the same time the clay soil has greater power of holding the moisture than a sandy soil.
         d. Sandy soil requires more frequent rains or more frequent application of irrigation water.
      3. **Air.**
         a. Air is necessary for plant growth, and free circulation of air should surround the roots of a plant as well as the foliage.
         b. If the soil is compact or water-logged, the air cannot free-

ly penetrate and the plants will not thrive under these conditions.

c. The conditions regarding air in the soil can be made more favorable for the growth of plants by thoroughly stirring.

d. If plants are crowded for room, we find that the foliage is not so luxuriant, neither is the growth so vigorous as where more space is given.

e. It is possible by proper methods of cultivation to give the plant roots more air and by judicious planting, to give more air to the foliage.

4. **Sunshine.**

a. The amount of sunshine which a plant receives is very important as regards the growth of the plant.

b. Without sunshine it is impossible for plants to assimilate carbon dioxide and build up plant tissue.

c. Plants absorb carbon dioxide through the leaves, and this is changed to carbohydrates by the action of sunshine.

d. The amount of sunshine which the land receives during the day is not under the control, but the amount which the individual plant receives can be controlled within limits, and this depends largely upon the amount of space given the plant.

2. **Second Comparison.**

a. Trees begin early in the spring and continue to grow until late fall, so that fruit, leaf, and wood have a longer period in which to develop than annual and biennial crops.

b. There would seem to be less need for highly concentrated foods for the slow growing crops.

3. **Third Comparison.**

a. The roots of trees run much deeper in the soil and probably spread as far as those of the succulent plants.

b. The larger root-run and feeding ground should enable trees to thrive with less artificial feeding than is necessary with farm crops.

c. That trees can grow vigorously under natural conditions in poor soil for a long time, is an indication of their ability to obtain more nourishment from soil than farm crops.

d. **Essential factors for both.**

1. **Space.**

a. Other conditions being favorable, the largest individual plant is secured when it has unlimited space at its disposal for the extent of foliage and roots.

b. By increasing the number of plants per acre, the size of the individual plant is decreased, but the yield per acre is increased up to a certain point on account of the increase of the number of plants.

c. The space offered the roots depends upon the distance between the plants and the depth of soil to which the roots may penetrate.

d. Not only is the amount of water available to the plant increased as the roots go deeper, but the amount of plant food is also increased with the bulk of soil which the roots penetrate.

e. Loosening a fine soil or compacting a coarse soil, increases the amount of water which it will hold.

f. The quantity of water in the soil at any given time depends upon the location; the character of the soil; the treatment which it has received, and the rainfall or the amount of water applied artificially.

2. **Physical conditions.**

a. The physical conditions of the soil determine the amount of moisture which it absorbs and holds, and the penetration of the air into it.

b. Air is necessary both for the roots of plants and for the changes in the soil which are essential to its productiveness.

c. A heavy soil may be made more easily workable by the application of manure, and it is interesting to note that light, sandy soils are improved in the same way.

d. The physical condition depends to a limited extent upon its physical compositions; its chemical composition; its biological conditions, and the treatment to which it has been subjected.

3. **Biological conditions.**

a. In good agricultural soils we find bacteria which play a very important part in soil fertility.

b. They set up fermentation in the soil, decomposing organic matter, forming organic acids which react with the mineral ingredients in the soil, decomposing them and making them available to the plants.

c. The nitrogenous substances in organic matter are converted into ammonia compounds and eventually to nitric acid, or salts of nitric acid, making the nitrogen available to the plants.

d. **The nitrogen-fixing bacteria.**

1. They are capable of fixing the free nitrogen of the atmosphere, making it available, as plant food, while the nitrifying bacteria work upon the organic nitrogen, or the fixed nitrogen, which is already present in the soil, converting it into nitric acid or salts of nitric acid.

2. The nitrogen-fixing bacteria which are harbored by the legumes should not be confused with the nitrifying bacteria which are present in the soil.

3. Certain kinds of bacteria are capable of converting fixed nitrogen to nitrous acid, or salts of nitrous acid, while another set convert these compounds to nitric acid or salts of nitric acid.

4. **Other factors.**

a. The action is most rapid in a damp soil, and ceases entirely if the soil is air dried.

b. Bright light suspends the action and eventually destroys the bacteria.

c. Free supplies of oxygen are necessary, hence nitrification cannot take place in boggy soils, nor can it

take place in strongly alkalied soils or water-logged soils.

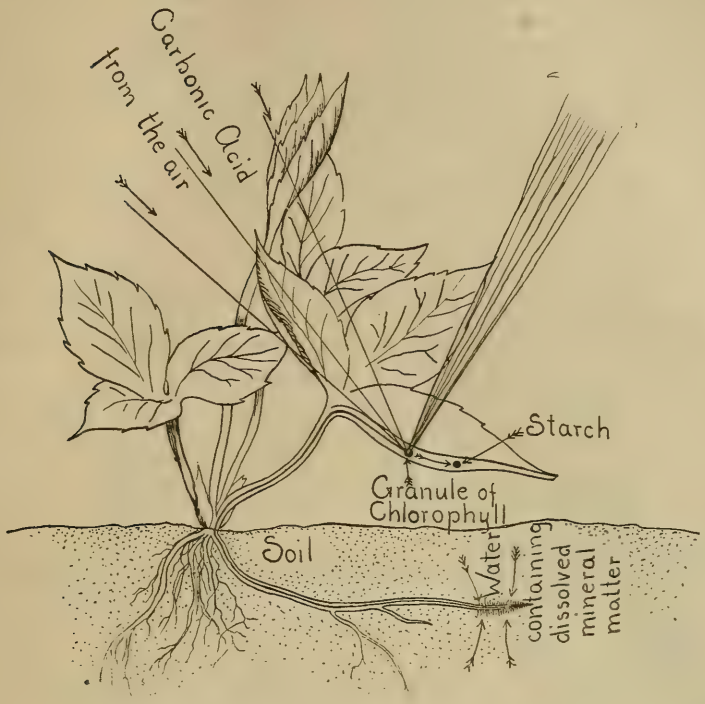


Fig. 30.—Shows the formation of plant food.—(Goff and Mayne.)

e. **Using the above figure,** explain the following:

1. Plants derive their food both from the air and from the soil. How?
2. The elements derived from the air are carbon-dioxide, oxygen. How?
3. Those derived from the soil are taken up through the roots, and are as follows: Phosphorus in the form of phosphoric acid, or its salts (probably an acid calcium phosphate), potash, nitrogen (in combination as a salt of nitric acid), lime, iron, sulphur, chlorine, and magnesia. How?
4. If any of these substances are withheld, the plant ceases to grow, or at best, makes a very sickly growth. Why?
5. The elements which are liable to be deficient in the soils of the arid and semi-arid countries are phosphoric acid and nitrogen.

4. **Fourth Comparison.**

a. Trees probably transpire larger quantities of water than herbaceous crops.

b. The more woody and fibrous the plant, the greater the number of tons of water required for a ton of dry matter.
c. The relatively great number of stomata on the leaves of fruit trees indicate that the fruit trees are "heavy drinkers" and transpire a greater amount of water in proportion to their leaf-areas than succulent plants.
d. The nutritive soil solutions may be less concentrated for fruit trees than for grass and vegetable crop.
e. See irrigation.

5. **Fifth comparison.**
   a. The fruit crops have a greater per cent of water than field crops.
   b. Apples are about 85 per cent water.
   c. The fruit crops require smaller amount of solid and mineral matter than field crops.
   d. **Tabulation of the elements** that the different fruit crops remove from the soil by one acre of orchard.

Name	Nitrogen	Phos. Acid	Potash	Lime	Magnesium
Apple ..	51.5 lbs.	14 lbs.	55 lbs.	57 lbs.	23 lbs.
Peach ..	74.5 lbs.	18 lbs.	72 lbs.	114 lbs	35 lbs.
Pear ...	29.5 lbs.	7 lbs.	33 lbs.	38 lbs.	11 lbs.
Plum ...	29.5 lbs.	8.5 lbs.	38 lbs.	41 lbs.	13 lbs.

   e. Study the above table.
      1. Which crop removes the greatest amount of plant food?
      2. What fertilizer is needed for apples? Peach? Pears? Plums?
   f. The three elements that must be supplied to soil by commercial fertilizers are nitrogen, potash, and phosphoric acid.

6. **Sixth comparison.**
   a. Fruit crops are a continuous cropping of one kind.
   b. There being no opportunity to change the crop to some other which might require different amounts of the plant-food constituents.
   c. It seems certain that nitrogen at least must have to be replaced.
   d. **Cultivated crops in an orchard.**
      1. Space of three to four feet should be left on each side of each row of trees.
      2. Early maturing crops are the best kind to grow because late cultivation for late maturing crops may cause large growth of the trees and if this growth fails to ripen, the trees may be winter killed.
      3. It will give to the orchard thorough cultivation.
      4. They will afford a shade to the newly planted tree at the season when it most needs the portection from the sun's greatest heat.
      5. The physical condition of the soil will be improved.
      6. Such crops as corn, potatoes, cabbage, etc., may be grown to an advantage.
   e. **Cover crops in an orchard.**
      1. Important uses of a cover crop.
         a. Covering the ground when the tree growth is not very active or entirely dormant.

b. They check the growth of the trees in the fall and cause them to ripen their wood.
c. They hold the soluble plant food which might leach out by drainage in late fall and early spring.
d. They catch the rain and conduct it into the soil and prevent the soil washing away.
e. They hold the snow for further protection of the soil.
f. They protect the ground from deep freezing.
g. They add vegetable matter to the soil.

2. **Humus improves the physical conditions.**
a. It loosens up the soil particles and prevents cementing or puddling.
b. It increases the water holding power of the soil.
c. It provides a favorable home for soil bacteria.
d. It furnishes elements of plant food in available form.
e. It assists in breaking up chemical compounds of plant foods.
f. Humus is the final product of organic decay.

3. **Classification of crops.**
a. **Leguminous plants.**
1. Crops—clover, vetches, alfalfa, cowpeas, soy beans, etc.
2. These crops are nitrogen gatherers, because special forms of soil bacteria associate with them and extract free nitrogen from the air and store it in tubercles on the plant roots.
3. If the soil is deficient in nitrogen, these bacteria form many tubercles on the roots of the plant, but if the soil is well supplied with humus and nitrogen they form fewer tubercles on the roots.
4. This class of plants returns large amounts of potash, nitrogen and humus to the soil.

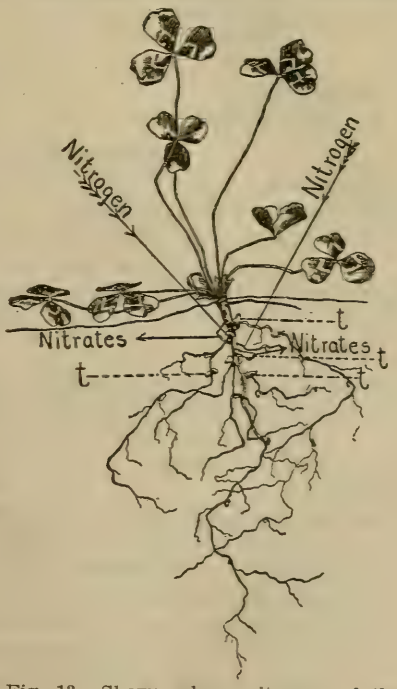


Fig. 13.—Shows where nitrogen of the air is changed to nitrates.

b. **Potash plants.**
1. Crops — cowhorn, turnips, and rape.
2. They are gross feeders and take up cruder forms of plant food than the more delicate nitrogen gatherers.
3. They store up some nitrogen, potash, and some phosphoric acid.

c. **Ordinary plants.**
1. Crops—rye, oats, wheat, buckwheat, etc.
2. They are useful when enough nitrogen is stored in the ground, as a winter cover or to return humus to the soil where only the physical texture needs to be improved.

4. Cover crops furnish nitrogen, potash and phosphoric acid to the soil.

5. **Amount of fertilizers in each crop.**

	Cowhorn Turnips pounds.	Rape pounds.	Crimson Clover pounds.	Red Clover pounds.	Alfalfa pounds.	Hairy Vetch pounds.	Cowpeas pounds.	Soy Beans pounds.
Nitrogen	109.5	129.4	134.4	103.0	95.2	121.2	69.5	140.2
Equal to Nitrate of Soda (16%)	684.2	808.8	840.0	643.8	595.0	757.5	433.4	876.2
Phosphoric Acid	26.0	46.9	61.2	29.0	21.6	27.2	18.9	40.2
Equal to Acid Phosphate (14%)	185.7	335.0	437.1	207.1	154.3	194.3	135.0	287.1
Potash	142.6	161.3	88.2	56.4	41.7	85.5	49.8	48.0
Equal to Muriate of Potash (50%)	285.2	322.6	176.4	112.8	83.4	171.0	99.6	96.0

6. **What and when to plant.**
a. In general, if the trees make good growth, but if the soil lacks humus as shown by it not being friable or mealy, then plant such crops as winter wheat or rye.
b. If the ground seems friable or mealy and loamy, but the trees do not make proper growth, the tree lacks nitrogen yet there is plenty of humus in the soil; in this case plant a legume as Russian hairy vetch.
c. Plant cover crops in July or early August and let grow until late spring, then turn under.

7. **References.**
a. See Soil Fertility.

PROPAGATION OF PLANTS.

1. **Purposes.**
a. Reproduction of plants.
b. Perpetuated valuable varieties.
c. Aid nature in producing good stock.

2. **Means by which plants are reproduced.**

a. **Natural reproduction.**

1. **Rootstock.**
a. Many species of plants are reproduced by means of rootstocks which push out laterally in all directions from parent plant, developing rootlets and throwing up stems; as, Johnson grass, and Bermuda grass.

2. **Stolens.**
a. Some plants throw out trailing branches or runners, which take root and produce new plants.
b. Examples—strawberry, raspberry.

3. **Suckers and root-sprouts.**
a. Plants reproduce by means of suckers and sprouts.
b. Plants like red raspberry, blackberry and some plums.
c. Plants reproduced by cuttings grow by means of root sprouts; as willows, poplars.

4. **Bulbs and corms.**
a. A bulb is a short rudimentary axis encased in more or less close

fitting, fleshy leaves or bulb scales, in which is stored up nutriment to be used in subsequent growth.

b. Bulbs usually form at or just beneath the surface of the ground.

c. They may be divided into two general classes.

1. Those composed of scales which are more or less narrow and loose, as in the lily.
2. Those composed of more or less continuous and close fitting layers or plates, as in the onion.

d. Bulbs often divide naturally into two or more parts, or may be so divided artificially, each of which part serves the purpose of a complete bulb in propagation.

e. Bulbs are often caused to produce bulblets artificially by wounding or mutilating them.

f. A corm resembles a bulb in appearance, but differs from it in being solid throughout.

g. Small corms, or cormels, are developed in very much the same manner as are daughter bulbs.

h. Examples of corm-producing plants are the Indian turnip, crocus, gladiolus and caladium.

5. **Spores are not true seeds.**

a. They are the means of reproduction of a great number of species, such, for instance, as ferns and the various fungi.

b. Mushrooms are the most important class of cultivated plants which depend on spores for reproduction.

Exercise 4.

1. **Object:** To show how spores are developed.
2. **Method:**

a. Spores can be developed easily by cutting a potato in two, rubbing lightly the freshly cut surface of one-half with a piece of moldy bread and putting it on a plate under an inverted tumbler.

b. Keep this covered potato in a warm, but rather dark place, for several days, examining it every few hours to note progress in the growth of the mold.

c. A heavy growth of mold grows in two or three days.

d. Little globular spore-cases will grow at the tops of slender branches which spring up from a network of whitish threadlike material.

e. Observe spore cases to see if any change occurs in them as they mature.

f. Study molds by using a microscope if available.

g. The rusty spots seen near the margins of fern leaves are spore cases.

h. When you step on a puffball it sends up a cloud of spores.

b. **Artificial reproduction.**

1. Glass buildings.
2. Frame buildings.
3. Hot-beds.
4. Cold frame and forcing hills.
5. Management of buildings.

6. The process to be used, is chosen with reference to:

a. No. of buds.	b. Seasons.	c. Condition of material.
1. Cutting — one to several.	1. All year except July and August.	1. Dormant or growing.
2. Grafting — two or more.	2. Last month of winter or first or second of spring.	2. Scions — dormant, stock-dormant or growing.
3. Layering — one to several.	3. Spring and winter.	3. Growing.
4. Budding—one.	4. Early and late summer.	4. Growing or dormant preferably the first.

CUTTINGS.

1. **Kind of cuttings.**

a. **Forms of hard-wood cuttings.**

Fig 32—Cuttings: a, simple cutting; b, heel cutting; c, mallet cutting; d, single-eye cutting.

1. **Simple cutting.**
   a. The most common form of hard-wood cuttings is that usually employed in propagating the grape and currant.
   b. Such a cutting consists of a straight portion of a shoot or cane nearly uniform in size throughout and containing two or more buds.
   c. At the lower end it is usually cut off just below a bud, because roots develop most readily from the joints.
   d. At the top it is usually cut off some distance above the highest bud.
2. **The heel cutting.**
   a. A cutting of this form consists of the lower portion of a branch,

containing two or more buds, cut off from the parent branch in such a manner as to carry with it a small portion of that branch forming the so-called "heel."

3. **The mallet cutting.**
   a. A cutting of this form is produced by severing the parent branch above and below a shoot, so as to leave a section of it on the base of the cutting.
   b. The principal advantage in the use of the heel and mallet cuttings lies in the greater certainty of developing roots.
   c. The principal drawback is that only one cutting can be made from each lateral branch.
4. **Single-eye cutting.**
   a. It is used to make the largest number of cuttings containing but one bud each.
   b. Such cuttings are commonly started under glass with bottom heat either in greenhouse or hotbed.
   c. They may be set in either horizontal position with the bud on the upper side or perpendicularly.
   d. In either case the bud is placed about an inch below the surface of the ground in soil which should be kept uniformly moist.
5. **Treatment of hard-wood cuttings.**
   a. Cuttings are usually made with two or more buds.
   b. Spring cuttings are made and then set out in nursery rows.
   c. Fall cuttings are tied together in bundles of 25 to 50 with butts one way; and,
   d. They should be buried out of doors or put in moist sand or sawdust in the cellar with tips down.
   e. The top buds are protected from freezing and the butts receive the benefit of the warmth of the sun in the spring, thus stimulating root growth.
   f. In the spring, the fall cuttings are set out about six inches apart in a trench with only the topmost bud or buds above the surface.
   g. Fine mellow soil is packed tightly around them from three to four inches deep.
   h. In planting, the cuttings should be exposed to light and air as little as possible.

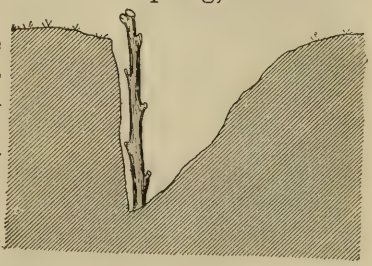


Fig. 33, Cutting set in trench

Exercise 5.

1. **Object:** To show hard-wood cuttings.
2. **Method:**
   a. At any time when they are dormant, take from last year's vigorous, thrifty, mature growth, cuttings of the grapes, flowering shrubs, gooseberries, currants, willows, poplars, etc.
   b. Let the cuttings be from 6 to 8 inches long.
   c. Let the lower cut be made just below the last node.
   d. Tie them in bundles of twenty to twenty-five, label, and pack in boxes of green sawdust or moist sand, and place in a cool place if the cuttings are taken before spring.

e. When spring comes the cuttings may be started in a propagation box or out of doors.
f. Plant in a slanting position, leaving the last node above the ground.

Fig. 34, Shows greenwood cuttings.

g. Press the soil firmly around the base of the cuttings.
h. Plant two or three inches apart in the row and the rows four feet apart.
i. Cultivate during the season.
j. Transplant at the end of one season's growth.

b. **Soft-wood cuttings.**

1. This class of cuttings is exemplified in the "slips" used to increase the number of house plants.
2. Many greenhouse plants, including roses, carnations, geraniums, chrysanthemums, fuchsias, begonias, and the like are propagated in this way.
3. This method of propagation can be employed in the winter time under glass.
4. Near the large cities the propagation of ornamental plants for use on lawns or in parks, yards, and gardens, has become an important and remunerative business.

Exercise 6.

1. **Object**; To show soft-wood cuttings.
2. **Method:**
   a. Make a frame 15 to 20 inches wide, 8 inches high at one side, 12 inches high at the other; long as the width of the window; tight bot-

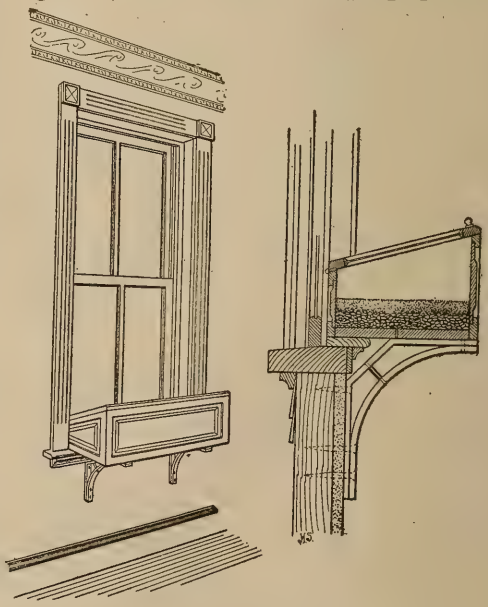


Fig. 35, Frame to show rooting cuttings.

tom; 3 or 4 one-half inch holes in the bottom.

b. Depth of the sand to be used in the propagation bed varies with the plants to be propagated, but usually an inch of broken stone or coarse gravel overlaid with 2½ to 3 inches of sand will be found amply sufficient for all soft-wood cuttings.

c. A confined atmosphere over the tops is especially required in propagating plants, which have leaves that are thin and liable to wilt easily; also for herbaceous cuttings which require a long period in which to form roots; and those from soft-wood which suffer from exposure.

d. Such a close atmosphere can be secured by means of a sash supported by a tight frame.

e. The simplest device for use in a small way is the bell glass.

f. Single cuttings may be covered with inverted glass jars.

g. If the trouble known as "damping off" develops in connection with this work, the sand should be removed, the inside of the box or frame should be scrubbed and white-washed, and fresh sand should be put in.

c. **Leaf cuttings.**

1. Some plants may be propagated by inserting the edge of a leaf or even a piece of a leaf in sand and supplying it with moisture.
2. Plants will spring up at the broken edges of the leaf or at cut places in the veins.

Fig. 36 Leaf cutting; part of leaf.

Exercise 7.

1. **Object:** To show leaf cuttings.
2. **Method:**
   a. Take most any very fleshy leaf, preferable one of a begonia, and peg down upon moist sand.
   b. Use toothpicks and peg down across the main veins being sure to break the veins.
   c. Bury the base of the leaf in the soil.

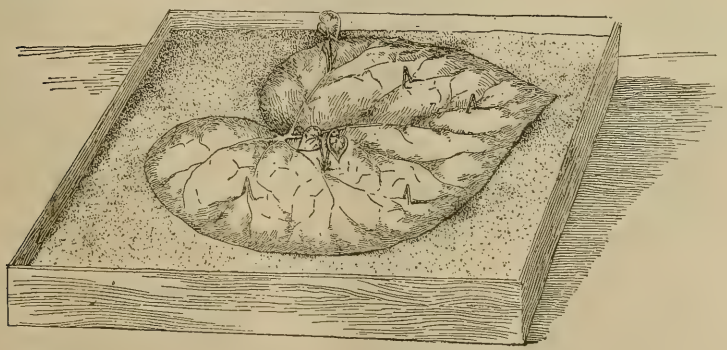


Fig. 37, Leaf cutting; whole leaf.

d. In a little while roots will be thrown out at the cut ends of the veins and new plants will form.

d. **Stem cuttings.**

Exercise 8.

1. **Object:** To show stem cuttings.
2. **Method:**
   a. Use thrifty shoots from the growing rose, geranium, coleus, tomato, nasturtium, potato, etc.
   b. Divide these shoots into cuttings having at least two nodes each, letting the lower cut be through the stem just below the lower node.
   c. Reduce the leaf surface to check evaporation by removing the leaves of the lower half of the cutting.

Fig. 38, Stem cutting or "slip" of coleus.

   d. Insert the cuttings in the soil to about one-half their depth and firm the soil around them.
   e. Plant one inch apart each way.
   f. Keep uniformly moist and when the roots are about an inch long transplant to larger quarters.

e. **Root cuttings.**

Exercise 9.

1. **Object:** To show root cuttings.
   a. Explain where the roots started.
2. **Methods:**
   a. All plants which sprout from the roots may be propagated by means of root cuttings.
   b. Examples of these are horse-radish, rhubarb, blackberries, quince, sweet potatoes, etc.
   c. Make cuttings from the roots two to three inches long, planting horizontally, close together and cover with two or three inches of soil.
   d. Most of these do best when started with bottom heat.

Fig. 39, shows roots and buds propagated from a root cutting.

GRAFTING.

1. **Principles.**
   a. The cambium layer of the graft must coincide with that of the stock in at least one place.
   b. A moderate pressure must be provided for this union to take place.
   c. All exposed surfaces must be protected by some means of covering.
   d. Grafting, unlike budding, is usually performed during the dormant period of growth, generally in the spring.
   e. It is accomplished by carefully fitting a small dormant twig or scion of the variety we wish to propagate into a cut in a stock, or seedling tree which we wish to change.
   f. There are several forms of grafting, but they differ more in

method than in results, in fact, so far as the top of the tree is concerned the results are the same in all cases whether we bud or graft.

g. The object sought is to change an undesirable or uncertain tree into one which we know will produce a variety whose fruit will possess certain desirable characteristics.

h. **The scion and its treatment.** Fig 40.

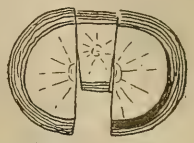


Fig. 40, Cross section of stock and scion.

1. A scion is a portion cut from a plant to be inserted upon another (or the same) plant with the intention that it will grow.
2. Point out the scion and stock in Fig. 40.
3. Explain how the scion is put into the stock.
4. Except for herbaceous grafting the wood for scions should be taken while in a dormant or resting condition.
5. The time usually considered best is after the leaves have fallen, but before severe freezing bgins.
6. The scions are tied in bunches and buried in moist sand, where they will not freeze and yet will be kept cold enough to prevent growth.
7. Good results often follow cutting scions in the spring just before or at the time the grafting is to be done.
8. If cleft grafting is the style to be employed, this practice frequently gives good results, but spring cutting of scions for whip grafting is not desirable, as not enough time is given for the proper healing of the wound before planting time in the spring.

i. The stock and its treatment.

1. The stock is the plant or part of a plant upon which or into which the bud or scion is inserted.
2. For best results in grafting it is essential that the stock be in an active condition, or so that active growth can be quickly brought about.

2. **Kinds of grafting.**

a. **Splice grafting.**

Exercise 10.

1. **Object:** To show splice grafting.
2. **Method:**
   a. This is a simple form of grafting.
   b. It is used when the stock and scion are very nearly the same size.
   c. It consists in splicing or lapping the scion on the stock by scarfing each at the same angle.
   d. When a close joint is secured the parts are held in place by means of some kind of wrapping material.

b. **Tongue grafting.**

Exercise 11.

1. **Object:** To show tongue grafting.
2. **Method:**
   a. This form differs from splice grafting in that both scion and stock are split at corresponding points on the scarf with a thin-bladed knife so as to form tongues.
   b. The object of this is to unite more firmly the two portions and

present a larger surface for the effusion of cell tissue, and to promote the callousing process.

c. This is the method commonly practiced by nurserymen under the name of root grafting.

Exercise 12.

1. **Object:** To show how sap travels up the stem.
2. **Method:**
   a. Color a glass of water with a good quality of red ink.
   b. Place some cuttings of live branches of maple or willow in this water over night.
   c. The next day split one of the branches and notice how the colored fluid has been drawn into and up these stems.
   d. Has it traveled upward in the bark, sapwood, or heartwood?
   e. What value is it to know that sap travels up the stem?

c. **Cleft grafting.**

1. **Top working.**
   a. Many trees, which did not come true to name and many varieties which are worthless may be made into popular varieties by top working.
   b. It takes about four years for the top-worked tree to grow as large as it originally was.
   c. Cut off the whole top of the tree.
   d. The argument that the grafting should run through a whole number of years is fallible. Fig. 41.
   e. If the old tree stock has been headed-in low, then you can use the scaffold limbs for the foundation upon which to put the scions.
   f. If the tree has been headed high, then cut off the whole top not higher than two feet from the ground.
   g. Do not try to top-work a tree that has a decayed trunk.

Fig. 41, shows transcendent crab grafted to winesap. (Paddock and Whipple).

   h. The time of top-working is in the spring extending from when the sap begins to ascend until early summer.
   i. The scion should be dormant.
   j. As the scion will grow rapidly, it is necessary that severe treatment be used to encourage lateral growths.
   k. Severe thinning out should also be practiced.

2. **Principles.**

a. This style of graft is particularly adapted to large trees when for any reason it becomes necessary to change the variety.

b. Branches too large to be worked by other methods can be cleft grafted.

c. Split the exposed end of the stock with a broad chisel or grafting tool. Fig. 42.

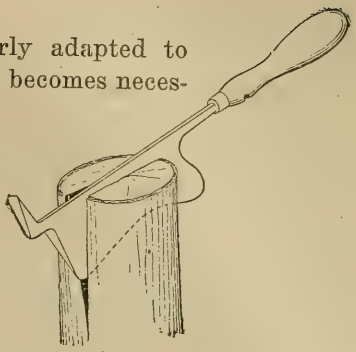


Fig. 42. Grafting tool inserted in the stock.

d. The scion should consist of a portion of the previous season's growth, and should be long enough to have two or three buds.

e. In general, it is a good plan to cut the scion so that the lowest bud will come just at the top of this wedge, so that in will be near the top of the stock.

f. If the proper pressure of the cleft be not sufficient to hold the scion in place, it must be wrapped with cloth or strings before waxing.

g. The stock and scion are now ready for the grafting wax, which may be applied, whether in liquid form with a brush or in plastic condition after having been worked with the hands, or they may be wrapped with strips of muslin or manila paper previously spread with wax, as heretofore mentioned.

Fig. 43, shows the same as Fig. 41 one year later. (Paddock and Whipple.)

h. Great care should be taken to make every joint air tight or the operation may be a failure.

Exercise 13.

Object: To show cleft grafting.

a. Study Fig. 44.
   1. Find the scion stock.
   2. Note the buds, where located.
   3. How is the scion put into the stock?

Method:

a. Should the limbs be no more than one to one and one-half inches in diameter, sever with a saw, being careful that the bark is not injured.

b. Split the exposed end with a broad chisel or grafting tool and then with a wedge spread the cleft so that the scion may be inserted.

Fig. 44, Cleft grafting: a, scion; b, scions inserted in cleft.

c. The scion should be cut wedge shape and outer edge thicker than the other.

d. The growing tissues of both scion and stock should have intimate contact.

e. Use two scions for each stock, inserting them each into the cleft and inclining them at a slight angle, as this gives a closer and surer contact between the cambium layers.

f. Take out the wedge, being sure that the scions are not dislodged.

g. Cover all the exposed portions with grafting wax.

d. **Bark grafting.**

1. A branch is sawed off, as for cleft grafting, and the scions, instead of being inserted in a cleft, are cut very thin and slipped between the bark and wood, being inserted far enough to bring the growing parts together.
2. The bark is then securely bound and wax is used as in cleft grafting.
3. This is called crown grafting by the English and French.
4. It is an excellent method for grafting larger limbs,

Fig. 45, Shows a well-formed grafted tree. (Paddock and Whipple.)

as it injures the stock less than cleft grafting and is easier performed, and also more scions may be inserted per limb.

Exercise 14.

1. **Object:** To show bark grafting.
2. **Method:**
   a. Cut off the tree where you desire to top-work it.
   b. Cut a vertical line through the bark of the stock about one inch long.
   c. Cut the scion on a bevel (not on a wedge) so that it is very thin.
   d. Insert the scion between the bark of the stock and the crown.
   e. Put in several scions this way in the same stub.
   f. Wax all the exposed surface and wrap a tight bandage around the base of the scions and the top of the stock in order to hold the scions close until they unite.
   g. The subsequent treatment is the same as for the cleft grafting.

e. **Saddle grafting.**

1. The stock is cut to a wedge-shape and the lower end of the scion is split and set upon the wedge, the place of union being tied and waxed.
2. This is for small limbs and nursery stock.

f. **Veneer grafting.**

1. The tip of the stock is removed with an abrupt slanting cut.
2. Then beginning at the highest portion of the top of the stock, cut a shaving which is thickest at its base, and which can only be removed by a sloping cut.
3. Cut the lower end of the scion in like manner and bind the two firmly together with waxed string.
4. When this style of graft is used as a root graft, no wax is necessary, but when used above ground the wound should be well covered.
5. This method of grafting is adapted to use in either summer or winter.

g. **Side grafting.**

1. The scion is cut wedge-shaped, as for cleft grafting, a chisel or a thick knife blade is forced into the stock, and the wedge of the scion is then forced into the incision.
2. Waxed string and wax are then used.

h. **Shield grafting or scion budding.**

1. The scion is cut very thin as in bark grafting, and is inserted under the bark of the stock as a bud is inserted in the process of budding and is firmly bound in place with waxed cord or raffia.

i. **Whip or root grafting.**

1. This style is called root grafting when the scion is grafted on the root and is the method practiced by nurserymen.
2. Thrifty 1 to 2-year-old stocks grown from seed are taken up in the fall and stored in a cellar or buried in the soil, where they will keep fresh and be accessible at any time in the winter when wanted.
3. The scions having been secured in the fall, the work of grafting may be performed at any time during the winter.
4. The roots only are used in this method, and they may be cut into

two or more sections, according to their size and length or the desire of the propagator.

5. But the larger or stronger roots, as a rule, may be relied upon for the most satisfactory results.
6. The scions may be cut much longer and the roots may be cut shorter and the graft planted so deep as to cause the roots to issue from the lower end of the scions.
7. When taken up to set in the orchard, the original root may be removed entirely, leaving nothing but the scion and the roots which have put forth from it.
8. When roots are cut into lengths of 2 to 6 inches to be used as stocks, the operation is called piece root.
9. In piece root grafting, the entire root is cut up into pieces, three or four inches long, thus furnishing material for two or three grafts.

Exercise 15.

1. **Object:** To show root grafting.
2. **Method:**
   a. By holding the stock or scion in the left hand, with the end supported by the index finger, a diagonal cut through the base of the scion or top of the stock may be made.
   b. Holding the wood in the same position, cut from one-third of the length from the outer end of this cut, making a vertical slit about an inch long.
   c. After the scion and stock are both thus prepared, carefully insert the tongue of the one into the slit of the other in such a manner as to bring the cambium layer of the scion in direct contact with that of the stock.

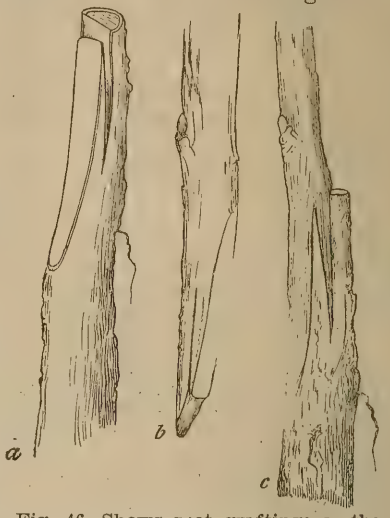


Fig. 46, Shows root grafting; a, the stock; b, the scion; c, stock and scion united.

   d. It is not necessary that the scion and stock be of the same size.
   e. More depends upon the smoothness of the cuts and the snugness of their fitting together than upon anything else.
   f. Wrap, so that the cut faces are kept in close contact, with No. 18 knitting cotton which has been previously dipped into grafting wax.
   g. The wrapping need not be over a foot in length.
   h. When the graft is finished, it will be about one foot long.
   i. The grafts should be tied in bundles and packed in sawdust or leaf-mold until planting time.
   j. At the point of union, little swollen lumps (callouses) should start to force a union
   k. The callouses may be hastened by putting the box of grafts in a warm room.
10. **After-culture of root grafts.**
   a. When the operation has been performed, the grafts are packed

away in moss, sawdust, or sand, in a cool cellar, to remain until spring.

b. It is important that the place of storage should be cool, else the grafts may start into growth, and be ruined, or heating and rotting occur.

c. If the temperature is kept low, not above 40° F., there will be no growth except callousing, and the knitting together of stock and scion.

d. This callousing must be commenced before the stocks are planted in the spring for it will not take place in the damp soil.

e. In ordinary propagation by means of whip grafts, the scion is cut with about three buds, and the stock nearly as long as the scion.

f. The ground in which the grafts are planted should be plowed deep and very thoroughly pulverized.

g. The root grafts should be planted about four to six inches apart in the row and the rows three and one-half to four feet apart.

h. Be sure to press the soil firmly around the roots.

i. They should be planted deep enough so that but one bud appears above the ground.

j. Every effort should be centered upon making the grafts grow.

k. The best treatment for this is to cultivate, often, deeply and thoroughly.

l. No danger of overdoing the cultivation.

m. **Results.**

1. As the plants grow they will first form, as a rule, one upright leader.
2. If more than one leader starts, trim to one leader.
3. Later, at the axil of each leaf, a lateral branch will start.
4. Rub the lateral off, but do not rub any leaves off.
5. From now on, it will necessitate someone going over the stock every two weeks to rub off the laterals.
6. Under no consideration let the laterals remain.
7. If you rub off the leaves, the plant will not grow so fast and it will also be very spindling.
8. At the end of the season you will have one-year-old nursery stock, the best kind to plant for an orchard.
9. Of course, there will be some very small trees in the nursery rows.
10. These may be kept for the second year.

o. If this is done, in the next spring, cut them back to one strong bud above the graft and let them grow, treating them subsequently as if they were the other grafts.

BUDDING.

1. **Budding is meant** to take the bud from the plant which one desires to grow and to insert it into the bark of some allied specie plant in which it is to grow.
2. This must be done when the bark peels easily in the spring and to early fall.
3. This operation consists in removing a bud from a twig of the variety which we wish to propagate and inserting it beneath the bark

of the stock or young seedling tree we wish to change; and this is then held in place by tying it fast until the bud and stock unite.

4. The expense of the operation is, therefore, not more than that of whip grafting, although the work has usually to be done in July, August, or early September.
5. **The bud.**
   a. The bud should be taken from wood of the present season's growth, and in a good state of maturity.
   b. Since the work of budding is done during the season of active growth, the bud sticks are prepared so that the petiole or stem or each leaf is left attached to serve as a handle to aid in pushing the bud in place when inserting it beneath the bark of the stock.
   c. This is what is usually called a shield bud and is cut so that a small portion of the woody tissue of the branch is removed with the bud.
6. **The stock.**
   a. The stock for budding should be at least as thick as an ordinary lead pencil, and in a healthy growing condition.
   b. With the apple and pear a second season's growth will be necessary to develop this size, while with the peach a single season will suffice; hence peach stocks can be budded the same season the pits are planted.

Fig. 47, a bud stick.

   c. Consequently the peach is left until as late in the season as is practicable in order to obtain stocks of suitable size.
7. **June budding.**
   a. If it is desired to start the bud into growth the same season it is inserted, the budding should be done as early in the season as well-developed buds can be obtained from growing trees.
   b. As soon as it is found that the bud has united with the stock or branch, the material used to fasten the bud in place must be removed and the stock or branch cut back to within a short distance from the bud, to force the growth of the inserted bud.
8. **Late fall budding.**
   a. This is the kind of budding more commonly practiced among nurserymen, the buds being inserted into the stock as late in the season as the bark of the stock will separate freely to receive it.
   b. In such instances the bud remains dormant through the following winter.
   c. The following spring, the wrapping is removed and wherever the buds appear sound, the tops of the stocks are cut back and treated in the same manner as described for June budding.
   d. All buds on the stocks below the one inserted should be rubbed off as they start to grow.
   e. The objection to early, or June budding, is that the growth from such buds does not always mature sufficiently in northern sections to pass a severely cold winter without injury.

Exercise 16.

1. **Object:** To show budding.
2. **Method:**

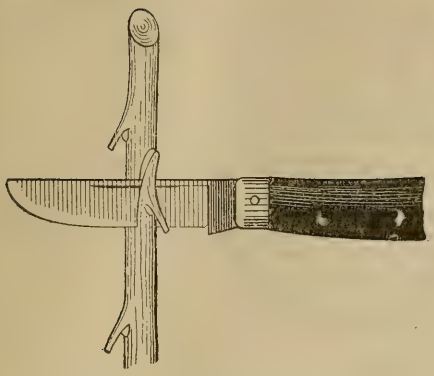


Fig. 48, Cutting the bud.

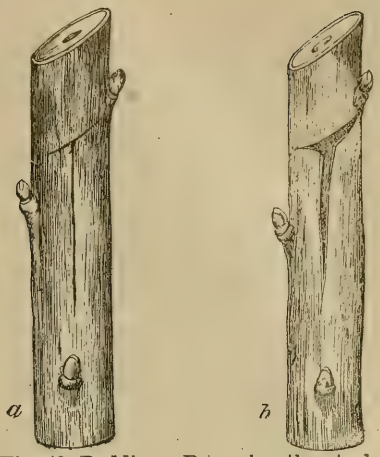


Fig. 49, Budding: Preparing the stock.

a. The strongest twigs of last year's growth should be selected while dormant and stored away in boxes of green sawdust or moist sand until the stock is in condition for inserting the buds.
b. The stock best suited for this work is one year old seedlings.
c. It should be used as soon as the bark will slip upon it; or as soon as the sap begins to rapidly ascend in the spring, or early summer.
d. The stock is prepared by making two incisions in the bark, one at right angles to the other, thus forming a T-shaped cut.
e. Make the cut on the north side for protection from the sun.
f. The bud is prepared by cutting off about one inch of bark and wood, paring off a small portion of the woody tissue with the bud.

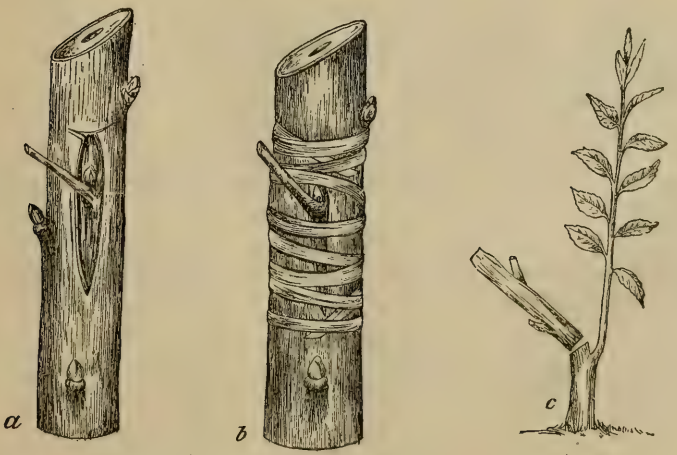


Fig. 50, Budding: a, Inserting the bud; b, tying; c, cutting off the top.

h. Loosen the flaps of the T-shaped cut on the stock and insert the bud under the flaps and push it firmly in place until its cut surface is entirely in contact with the peeled body of the stock.

i. Wrap with moist raffia, or bands of wrapping cotton about ten to twelve inches long, above and below the bud.

j. As soon as the bud has united with the stock, which ought to be done in ten days, cut the ligature to prevent girdling.

k. This done, the operation is finished until the next spring, when all the trees in which the buds have "taken" should have the top cut off just above the bud.

Formulas for Grafting Wax.

1. Formula No. 1 for outdoor work.
   a. Resin 4 to 5 parts, beeswax 1½ to 2 parts, linseed oil or tallow, 1 to 1½ parts.
   b. This is melted in a mass, and when cool enough it may be drawn out into thin strips and applied by wrapping it firmly around the stock where the scion is inserted.
   c. A more convenient mode of using this wax is to spread it while melted upon thin muslin or strong manila paper and when cool, cut or tear in strips of convenient width for wrapping around the grafted stock.
   d. When the wax is applied it should be melted but not hot enough to cook the tissue of the plant.
   e. The wax should be carefully spread over all cut or exposed surfaces and pressed closely so that it will form a sleek coating which will exclude air and moisture.
   f. Note:
      1. Waxed string may be prepared by dropping a ball of No. 18 cotton into a kettle of the above melted wax.
      2. In a few minutes, it will be thoroughly saturated, after which it may be taken out.
      3. It will remain in this condition indefinitely.
2. Formula No. 2 for indoor and outdoor work.
   a. Resin 6 pounds, beeswax 1 pound, linseed oil 1 pint.
   b. Melt together, and when at the temperature of 180° F. apply directly to the joints with a small bristle brush.
   c. In order to keep it at the proper consistency the vessel containing the wax may be placed in another vessel containing boiling water.

LAYER.

1. This is the common method of reproducing the strawberry, dewberry, black raspberry, etc.

Exercise 17.

1. **Object:** To show simple layering.
2. **Method:**

a. Bend down one of the lower shoots, placing it in a small depression and pegging it down with a forked stick, and covering with a few inches of mellow soil.

Fig. 51, Tip layering.

b. If the soil has been moist enough, roots will have started from each new node which has been covered up and a new plant may be secured by separating the new plant from the old.

Exercise 18.

1. **Object:** To show mound layering.
2. **Method:**
   a. The old plant is first cut off near the surface of the ground, before growth begins in the spring.
   b. By the following spring many shoots will have grown from the "stool."
   c. Next the stool or base of these shoots are mounded up with dirt for several inches.

Fig. 52, Mound layering.

   d. Roots will form at the underground nodes of these, the same summer as they are mounded up.
   e. In fall or the following spring, the newly rooted shoots may be removed from the stool and planted as new plants.
   f. The old stool may be used to produce more plants the ensuing year.

Exercise 19.

1. **Object:** To show vine layering.
2. **Method:**
   a. Stretch a vine along the ground, burying its entire length in a shallow trench or covering it in certain places, leaving the remaining portion exposed.
   b. Roots will be put forth at intervals and branches thrown up.
   c. Later cut the vine between these, leaving a number of independent plants.
   d. Grape and ivies may be readily propagated in this way.

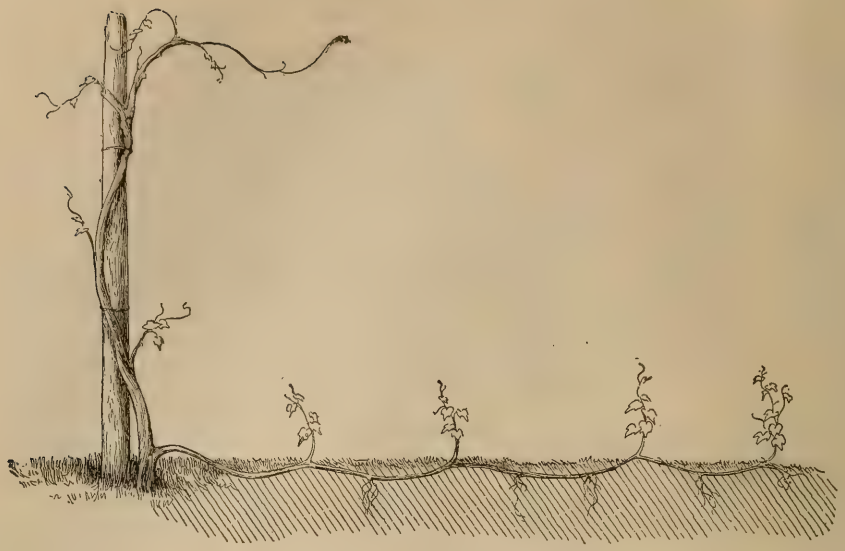


Fig. 53, Vine layering.

PLANT STUDY.

1. **Treatment** of seeds by stratification.
   a. The simplest and most common method pursued by the agriculturist is to prepare the soil and place in it the seeds of the future crop just where they are expected to grow and produce mature plants.

Fig. 54, Shows a good seed tester.

   b. This is the method employed in growing cereals, cotton, most forage crops, and many truck and garden crops as well as ornamental plants.
   c. With many cultivated plants, however, the seeds are planted in cold frames, hotbed or greenhouse, and the plants on reaching proper size are transplanted to field or garden.
   d. Nearly all orchard trees come from seeds originally planted in nursery beds, and later, after being budded or grafted, transplanted to the orchard.
   e. They are, in fact, usually transplanted one or more times before being finally put out in the orchard.
2. **Method:**
   a. Note carefully the outer coating of a number of different seeds, such as peas, corn, onions, beans, squashes, canna, locust, apples, peaches, plums, maples, catalpas, etc.
   b. Most hard shelled seeds are shed in the fall so that they may lay in the litter and be frosted open.

c. Those which hang on the tree all winter and fall, in the spring are usually seeds of soft texture and those which are not able to stand the rain without decaying.

3. **The process of germination by stratification.**
   a. Place layers of seeds alternating with layers of sand in a box.
   b. The box is buried, sheltered or covered with leaves or straw, to the depth of one foot.
   c. The covering of the seed is softened and decays.
   d. Freezing is beneficial, but alternate freezing and thawing are destructive to most seeds.
   e. Seeds should not be exposed to wind or sun.
   f. Seeds may be stratified in pits and covered with sod.
4. **Germination of seeds.**

Exercise 20.

1. **Object:** To study the effect of stratification upon the germination of seeds.
2. **Method:**
   a. In October or November take the seeds collected during the summer and place them in a shallow box which has previously had an inch or more of sand, leaf-mold, or even garden soil, placed in the bottom of it.
   b. Put on the seeds, then, a thin layer of sand, etc.
   c. Then add another layer of seeds.
   d. Then sand alternating until the box is full.
   e. Sink the box in the ground in some shady place, leaving uncovered to the action of the snow, rain and frost.
   f. When the weather permits, plant in rows in well prepared soil.
3. **Note:** Seeds require heat, moisture and air.

Exercise 21.

1. **Second method:**
   a. Should the seeds be procured too late in the year to stratify—
   b. They may be treated in another equally effective but slower way.
   c. Such seeds as those of the peach, plum, or cannas, may be made to sprout right away by filing them into the meat with a file.
   d. Care should be taken that the embryo is not injured.
   d. See first method.

Exercise 22.

1. **Object:** To germinate fine seeds.
2. **Method:**
   a. Seeds should be placed in shallow boxes about four inches deep.
   b. Fill these with soil made up of equal parts of garden loam, leaf mould and sand.
   c. Well-rotted manure may be used in the place of leaf-mould.
   d. Sow seeds on the surface of the soil pressing them in by the palm of the hand.
   e. Cover with a cloth, laying it flat on the surface of the soil.
   f. Sprinkle abundantly with water.

g. Cover with window glass, providing for the admission of air.
h. As soon as they have sprouted remove the cloth, and as soon as the true leaves appear transplant into more spacious quarters.

Exercise 23.

1. **Object:** To store acorns, nuts or seeds for spring planting.
2. **Method:**
   a. Gather a quart or more of acorns, nuts or seeds.
   b. Spread them out on a dirt floor in a cellar or shed for two or three weeks to dry.
   c. Then prepare a pit, on some well-drained spot, in which to store them.
   d. Make the pit about 14 inches deep and 10 to 12 inches square.
   e. Line the sides and bottom of the pit with boards or sink a box of the proper size into the hole, to keep out mice and squirrels.
   f. Cover the bottom with a layer of clean sand 2 or 3 inches deep.
   g. Spread a layer of nuts on this, then another layer of sand, and so on until all the nuts are stored.
   h. Then cover the hole with earth to a depth of from 4 to 6 inches and see that it is well heaped up and rounded so as to drain off all water.
   i. When the ground is ready for planting in the spring, remove the nuts from the pit and plant them immediately.

Exercise 24.

1. **Object:** To test the vitality of seeds.
2. **Method:**
   a. Gather a quantity of small seeds.
   b. Count out from 50 to 100 seeds and place them on a plate between two sheets of moist blotting paper.
   c. Record on a slip of paper the number and species of the seeds, with the date on which the test is begun.
   d. Place this slip on the edge of the plate, so it will not get lost or separated from the seeds it represents.
   e. Cover the whole with another plate or pane of glass.
   f. Keep in a warm room, in which the temperature is not less than 68°.
   g. Keep the blotting paper moist, but not saturated.
   h. Examine the seeds every day until all have had time to germinate.
   i. This may take two weeks or even longer.
   j. When the seeds are well sprouted, count out those which failed to germinate and from this determine the percentage of good seeds.

ORGANS OF VEGETATION.

I. Roots.

1. **Forms.**
   a. Primary.
   b. Secondary.
2. **Structure.**
   a. Magnified section, Fig. 55.
      1. a, cortex.
      2. b, central cylinder.
      3. e, endodermis.
      4. h, hair roots.
      5. ep, epidermis.
      6. sp, cut ends of the ducts.
      7. Medullary ray.
      8. Vascular cylinder.

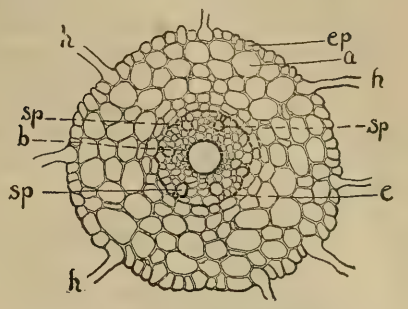


Fig. 55, Section of a root. (Andrew's Botany.)

   b. Study the cross-section of a root and point out the structural parts.
3. **Kind.**
   a. Tap-roots.
   b. Fibrous.
   c. Adventitious.
   d. Water roots.
   e. Haustoria.
   f. Aerial roots.
   g. Collect the different kinds of roots.

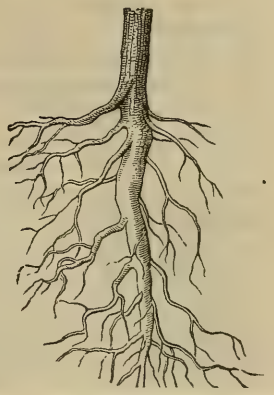


Fig. 57, Branched tap-root. (Andrew's Botany.)

4. **Adaptability of roots.**
   a. Adapted to soil.
   b. Adapted to water.
   c. Adapted to air.
   d. Adapted to parasite habits.
5. **Function.**
   a. Holding plants.
   b. Storage of foods.
   c. Absorption.
   d. Secretion.
   e. Conveyance.
6. Effect of soil on roots.
7. Effect of tillage on roots.
8. **Questions.**
   a. What is the use of pits in central cylinders?
   b. What is the use of bundles?
   c. What are the uses of hair roots?
   d. What is the use of the epidermis?
   e. What effect on the plant, if any or all parts of the plant are injured?

Fig. 56, Fibrous root. (Andrew's Botany.)

9. **Absorption power of roots.**

a. Osmosis.

1. **Form of diffusion.**
2. **Absorption.**
3. **Principles.**

a. Thinner and lighter liquids flow more rapidly into denser and heavier than the latter would into the former.
b. The flow depends upon density.
c. Solutions of crystalled substance diffuse more rapidly.
d. Albuminous substance slower.
e. Explain the pumping power of roots.

Exercise 25.

1. **Object:** To demonstrate the passage of solutions through tissues, animal or vegetable.
2. **Method:**
   a. Pick away the shell at the large end of an egg.
   b. Pierce a small hole through the opposite end of an egg.
   c. Place the glass tube over the hole and fasten with sealing wax.
   d. Place the egg in a glass of water so that the membrane is in contact with the water.
   e. Let stand for several hours.
   f. Note results.
3. **Questions.**
   a. Will starch, albumen, olive oil, sugar and salt diffuse through partition?
   b. What is diffusion?
   c. What is a dialysis?

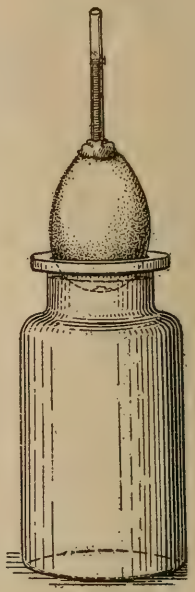


Fig. 58, Shows osmosis.

Exercise 26.

1. **Object:** See exercise 25.
2. **Method:**
   a. Tie a piece of moistened bladder over the end of tube A, as shown at B.
   b. Fill tube partly with molasses.
   c. Fill bottle partly full of water.
   d. Arrange tube as indicated in Fig. 59.
   e. Note:
      1. Exercises 25 and 26 show how water, laden with plant food enters the plant through the hair roots.
      2. Give results of both exercises.

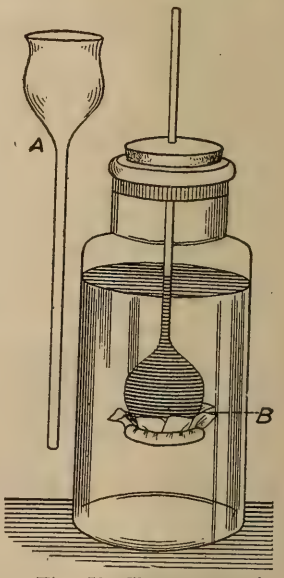


Fig. 59, Shows osmosis through bladder membrane.

Exercise 27.

1. **Object:** To show that plants get food from the soil.
2. **Method:**
   a. Burn all vegetable matter out of the sand.
   b. Fill tin cans with sand.
   c. Plant in each five beans which have been soaked over night.
   d. Water both cans as indicated and set in a warm place.
   e. Water one can with rain water when needed.

f. Water the one with soil solution which is made by mixing rich soil with water, making a thick slop, then strain off some of the water using muslin or cheese-cloth.
g. Continue to water each can for five weeks.

3. **Questions.**
   a. What makes the difference in growth?
   b. How is plant food dissolved in the soil?

10. **References.**
   a. Any Botany.
   b. Nursery Book by Bailey.
   c. Fruit Growing by Bailey.
   d. Fruit Growing by Paddock and Whipple.

2. Stems.

1. Classification.
   a. Duration.
      1. Annuals.
      2. Biennials.
      3. Perennials.
   b. Position.
      1. Erect.
      2. Prostrate.
      3. Root climbers.
      4. Tendril climber.
      5. Twining climber.
      6. Inclined.
      7. Declined.
      8. Underground.
      9. Functions.
      10. Relation to light.
      11. Relation to air.

2. Type of stems.
   a. Endogenous signifying to grow inwardly.
   b. Exogenous signifying to grow outwardly.

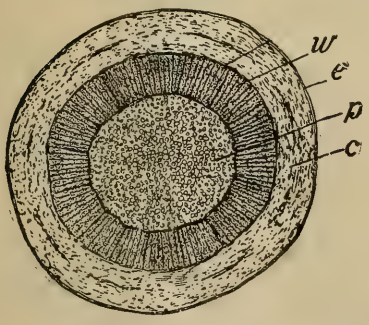


Fig. 60, Cross section of twig. (Andrew's Botany.)

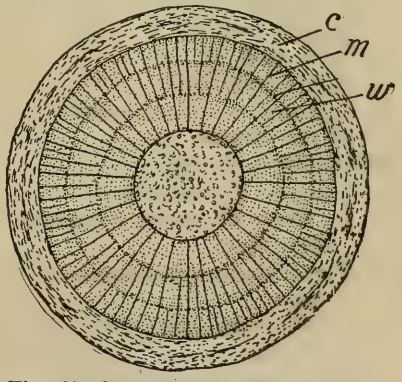


Fig. 61, Cross section of a twig three years old. (Andrew's Botany.)

   1. e, Epidermis or bark.
   2. c, Cortex.
      a. Soft bast.
      b. Lenticels.
   3. Cambium layer.
      a. Produces wood-cells and ducts on the in side.
      b. Produces new layers of bark on the out side.
   4. Woody vascular cylinder (w).
      a. Annular rings.
      b. Medullary rays.
   5. p, Pith.

   c. Study Fig. 61—shows stem three years old.

1. m, Shows the radiating lines which cross the vascular region (w) to the cortex (c).
2. The pith is obvious only in young stems.

d. Study the rings in Fig. 62.
1. Number of rings.
2. Number at top.
3. How do rings join with limbs?
4. Do the number of rings determine the age of the tree?

Fig. 62, Annual growth of a dicotyledon. (Andrew's Botany.)

3. **Modification.**
a. Stems as foliage.
b. Stems as weapon.
c. Stems as storage.
1. Fills office of leaf.
2. Fills office of stalk.
3. Fills office of water reservoir.
d. Underground stem.
1. Storage of nourishment.
2. Storage of moisture.
3. Preventing evaporation.
e. Rootstocks.
f. Tuber, illustrate.
g. Bulb, illustrate.

4. **Functions.**
a. Support framework of the plant.
b. Binds the different organs together.
c. Brings organs in right relation with light and air.
d. Storage of food.
e. Conveys sap from roots to other parts of the plant.

5. **Circulation of sap.**
a. Upward movement.
1. Through ducts in woody portion of the stem.
b. Downward movement of plant food in sap.
1. Through soft blast of the cortical layers.
c. Transpiration of leaves.
1. Causes sap to flow to leaves.
2. Causes osmotic flow.
d. Causes.
1. Pumping power of the roots.
2. Suction power of the leaves.
3. Capillary attraction.

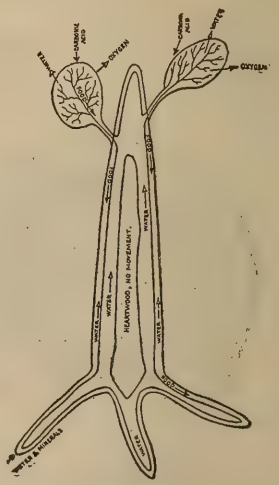


Fig. 63, Showing general movement of sap. (Andrews' Botany.)

6. **Ringing fruit trees.**
a. Effect on food above the ring?
b. Effect on food below the ring?
c. Effect on fruit?
d. Gives borers a better chance to work.
e. Effect of driving nails into plum and peach trees?

Exercise 28.

1. **Object:** To show that water circulates in the plant.
2. **Method:**
   a. Fill a tumbler about one-third full of lukewarm water, colored with red ink.
   b. Place a cut stem of soft green plant in the tumbler.
   c. In a short time the colored water will rise through the stem or twig and may be seen distributed in the veinlike patterns through the petals of the flower or the leaves.

Exercise 29.

1. **Object:** To show the effect of girdling on the tree.
2. **Method:**
   a. Early in the spring remove a strip of bark 2 inches wide around the trunk of the tree, leaving the wood entirely exposed.
   b. Be sure to cut through the inner bark so as to leave none of it connecting the bark above the girdle to that below.
   c. Watch the effect on the tree.
   d. Does it show signs of injury immediately or not until late in the summer or the next spring?
   e. What is the result eventually?
   f. Explain.
3. Note: Select some tree which is to be cut down.
   a. Do not try it on a good tree.
   b. Try on one or two minor branches of an unprofitable tree.

7. Make a collection of the different kind of stems.

Leaf.

1. **Form of leaf.**
   a. Simple.
   b. Compound.
2. **Parts of leaf.**
   a. Blade.
   b. Petiole.
   c. Stipules.
3. **Venation of leaves.**
   a. Vascular tissue.
   b. Midrib.
      1. Primary.
      2. Secondary.
   c. **Classes.**
      1. Nettled.
      2. Paralleled.
      3. Forked.
4. **Shape of leaves.**
   a. Name of nine shapes.
5. **Shape of base.**
   a. Rounded.
   b. Tapering
   c. Cordate.
   d. Truncate.
6. **Shape of apex.**
   a. Obtuse.
   b. Acute.
   c. Acuminate.
   d. Truncate.
7. **Shape of margin.**
   a. Entire.
   b. Undulate.
   c. Serrate.
   d. Dentate.
   e. Crenate.
   f. Lobed.

Exercise 30.

1. **Object:** To make leaf prints for laboratory study.
2. **Apparatus:** Large, smooth slate or thick glass 10x12 inches; tube of printer's ink; two six-inch rubber rollers; sheets of good quality white paper.
3. **Method:**
   a. Squeeze a few drops of the printer's ink from the tube upon

the glass or slate and spread it about with the roller until there is a thin, smooth coat of ink both upon the slate and upon the roller.

b. The ink should never be so thin that it will "run" since it will not then produce a good, clear print.

c. Now place the leaf on the inky surface of the glass and roll it once or twice on the upper side with the inky roller, until both surfaces of the leaf are well inked.

d. Lay the inked leaf upon a sheet of smooth white paper and cover it carefully with another sheet.

e. Take the clean roller and roll it once only, bearing on it hard.

f. An impression of the leaf will be made on both the upper and lower sheets of the paper.

4. **Note:**

a. This exercise may be amplified and made much more interesting by using oil colors, which may be brushed lightly over the lower side of the leaf, then press upon them by a roller.

b. The impression on paper is then made by rolling the "painted" leaf with a clean roller on white paper as in the printer's ink process.

c. The lower side of the leaf gives a better print, with this process, than the upper.

d. The colors used should be arranged just as they appear in the leaf itself.

8. **Arrangements.**

a. Opposite.

b. Whorled.

c. Alternate.

9. **Structure.**

a. Upper epidermis.

b. Inter-structure.

1. Chlorophyll.

2. Air spaces.

c. Lower epidermis.

1. Stomata.

Functions of the Leaves.

1. **Transpiration.**

Exercise 31.

1. **Object:** To show that plants give off moisture through their leaves.

2. **Method:**

a. Fill one tumbler with water.

b. Place a piece of cardboard over the tumbler.

c. Put the petiole through the cardboard into the water and seal all openings.

d. Invert the other tumbler over the plant.

e. Note the result after one hour.

f. What effect on plants if the leaves are injured?

2. **Photosynthesis.**
   a. Principle of binding up.
      1. Carbon dioxide is taken up and oxygen given off.
      2. Formation of starch.
      3. The process is performed by chlorophyll.
   b. Requirements for photosynthesis.
      1. Living plant cell.
      2. Carbonic acid gas.
      3. Chlorophyll.
      4. Sunlight.
      5. Water.
      6. Chemical change.
3. **Manufacture of foods.** Figures 30 and 31.
   a. Comparison of a leaf to a mill. (Bergen's Botany.)
      1. Mill—palisade-cell of the leaf.
      2. Raw material—carbon dioxide, water.
      3. Milling apparatus—chlorophyll grains.
      4. Energy by which the mill is run—sunlight.
      5. Manufacture product—starch.
      6. Waste product—oxygen.

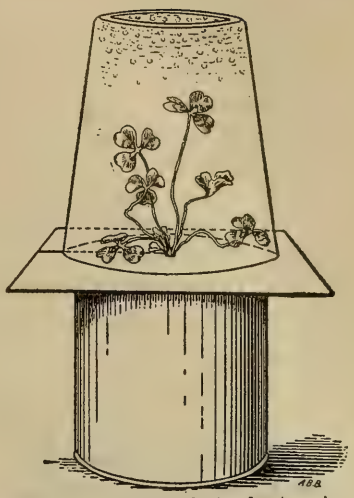


Fig. 64, Shows that plants give off part of the moisture absorbed from the soil through the leaves.

Exercise 32.

1. **Object:** To show that starch is in the leaves.
2. **Method:**
   a. Place a green leaf in the sunlight for a day.
   b. Then put the leaf in boiling water for a minute.
   c. Immerse it in alcohol.
   d. Apply iodine solution.
   e. Rinse the leaf in water.
   f. Notice the blue color of starch.

4. **Digestion.**
   a. Leaf diastase.
      1. Acts on starch.
5. **Assimilation.**
   a. Takes place in every living cell.
   b. Leaf or organs of assimilation.
      1. Formation of carbohydrates.
   c. Sulphates, phosphates, nitrates, etc., meet the carbohydrates in the leaf and are assimilated.
6. **Respiration.**
   a. Leaves are organs of respiration.
   b. Plant breathing.
      1. Taking in oxygen and giving off carbon dioxide.
   c. Stomata, openings for interchange of gases.
   d. Requires warmth.
   e. Phinciples.
      1. Oxygen is taken in and carbon dioxide set free.
      2. Carbon dioxide is formed by chemical change.
      3. Process takes place in all plants.

4. Process takes place in dark, as well as light.
5. It is a breaking-down process.

f. Note:

1. Blow through a tube into a dish of lime water and note results.
2. Lower a burning candle into a bottle. What happens?
3. Pour a little limewater into the bottle and shake.
4. Note results.
5. Let a dish of limewater remain over night exposed to the air.
6. What happens?

7. **Questions.**

a. What is the work of the leaves?
b. What keeps a plant rigid?
c. What is transpiration?
d. How much water must a plant take in to get enough food to make a pound of try plant tissue?
e. Plants are made mostly of what?
f. Name two kinds of foods. Give an example of each.
g. What is the test for starch? Of what is it composed?
h. Where is starch made in the plant? How do you know?
i. What is chorophyll and what is its use?
j. How does carbon dioxide get into the air?

8. **References.**

a. Any Botany.
b. Fruit Growing by Bailey.
c. Fruit Growing by Paddock and Whipple.
d. Lessons with Plants by Bailey.
e. Experiments with Plants by Osterhout.

Organ of Reproduction.

1. **Parts of a flower.**

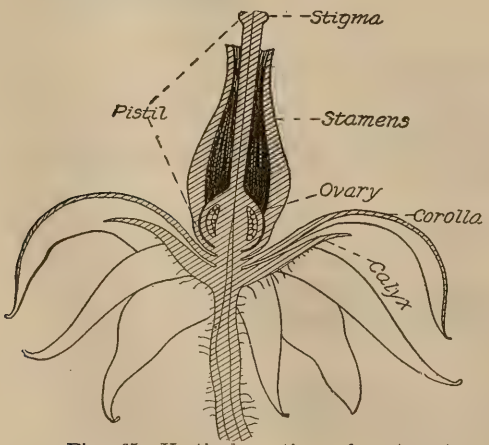


Fig. 65, Vertical section of a tomato blossom.

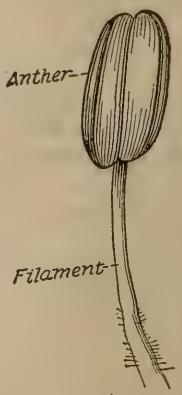


Fig. 66, A stamen.

a. **Calyx** (the cup).
   1. Sepal.
b. **Corolla** (blossom).
   1. Petal.
c. **Stamens.** Fig. 66.
   1. Anther.
   2. Pollen.
   3. Filament.
d. **Pistil.** Fig. 67.
   1. Ovary.
   2. Style.
   3. Stigma.

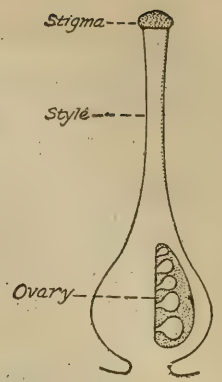


Fig. 67, A pistil.

2. **Essential organs.**
   a. Stamens (male organs).
      1. Anther (bearer of pollen).
   b. Pistils (female organs).
      1. Stigma (receiver of pollen).
3. **Kind of flowers.**
   a. Perfect has both stamens and pistil.
   b. Imperfect has stamens only or pistil only.
4. **Kind of flower-bearing plants.**
   a. Monoecious is a plant that has stamens and pistil in separate flowers on same plant.
   b. Dioecious is a plant that has stamens and pistil in separate flowers on different plants.
5. **Study of a flower.** Fig 68.
   a. Transverse section of an anther before its dehiscence.
   b. An anther dehiscing, with pollen.
   c. Filament.
   d. Base of floral leaves.
   e. Nectaries.
   f. Wall of carpels.
   g. Style.
   h. Stigma.
   i. Germinating pollen grains.
   m. A pollen tube which has reached and entered the micropyle of the ovule.
   n. A stalk of ovule.
   o. Base of the inverted ovule.
   p. Outer integument or testa.
   q. Inner integument.
   s. Rudimentary ovule.
   t. Cavity of the embryo sac.
   u. Its basal portion.
   v. Endosperm.
   z. Oosphere.

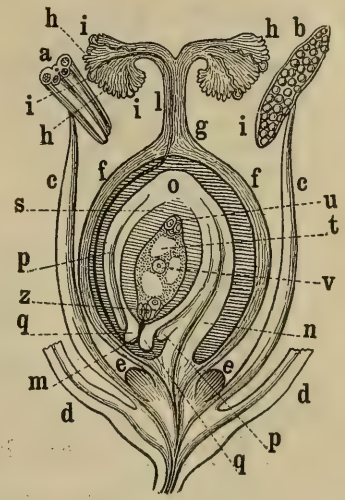


Fig. 68, Diagram of a simple flower. (Andrew's Botany.)

Pollination.

1. **Kind.**
   a. Close pollination.
   b. Cross pollination.
      1. By wind.
      2. By animals.
2. **Method.** Fig 69.
   a. Pollen tubes.
   b. Course of pollen tubes.
   c. Embryo sac.
   d. Germ cell.
   e. Union of two bodies (gametes).
      1. Egg cell in embryo sac.
      2. Pollen grains.
3. **Lack in setting fruit.**
   a. Lack of pollination.
   b. Inability of certain varieties to pollinate.
   c. Certain fruit spurs fail to produce fruit buds.
   d. Dropping of blossoms.
      1. Vegetative vigor of trees.
      2. Poor condition of trees.
      3. Insects and diseases.
      4. Rain or snow during blooming period.
      5. Spraying in blooming period.
   e. Climatic conditions.
      1. Winter freezes kill fruit buds.
      2. Spring frost injures fruit buds.
   f. Spraying when in full bloom.

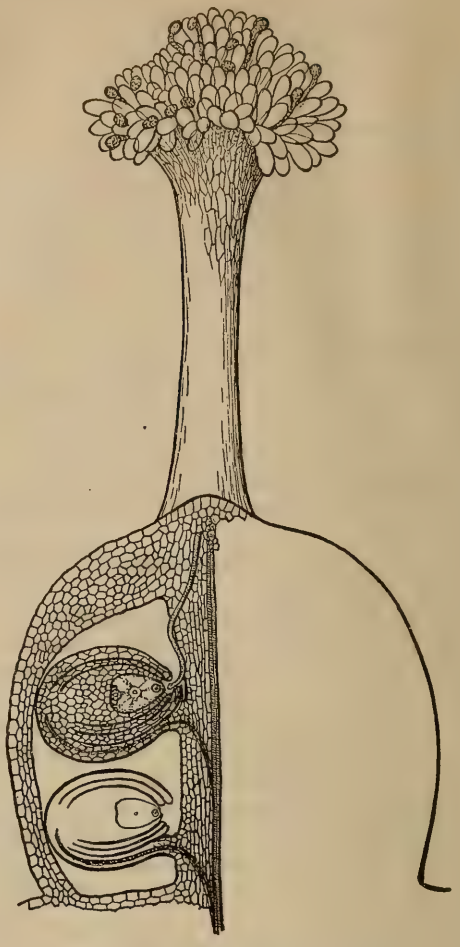


Fig. 69, Pollination of the ovules. (Goff and Mayne.)

4. **Essentials of good pollination.**
   a. Varieties must bloom at the same time.
   b. Varieties must have an affinity for each other.
   c. Varieties must be good pollen producers.
5. **Pollination of varieties.**
   a. Self-fertile is one which sets perfect fruit without the aid of pollen from some other variety.
   b. Self-sterile is one which does not set fruit without the aid of pollen from some other variety.
   c. Partially self-fertile or self-sterile is one which under certain conditions will set a limited number of fruit.

Mixed Planting.

1. **Many varieties** will not bear well alone.
   a. This is because they require the pollen from blossoms of other varieties.
   b. Since all varieties are benefited by cross-pollination, it is a good

thing to plant two, four, or six rows of one kind and then plant another kind.

c. It is best to plant two, four, or six rows rather than one, three, or five, as it facilitates the work when the number of rows are even.

d. This especially is true in spraying as the period of blossoming, and the time of spraying will vary slightly with each variety.

e. Plant varieties together which bloom near the same time.

f. When the following varieties are grown by themselves and set fruit, the fruit is inferior in size.

1. **Pears—Self-Sterile.**

Duchess.
Anjou.
Bartlett.
Clargeau.
Clapp.
Lawrence.
Winter Nellis.
Easter.
Doyonne.
Howell.

2. **Pears—Self-Sterile, partially.**

Bosc.
Manning.
Seckel.
Angouleme.
Flemish Beauty.
Le Comte.
Tyson.
White Doyonne.

3. **Self-Sterile Apples.**

Autumn Sweet
Arkansas Black
Bietigheimer
Bellflower (Yellow)
Chenanga Strawberry
Canada Sweet
Canada Reinette
Early Strawberry
Fallawater
Gravenstein
Gano
Hoover
Haas
Hyde's King
King
Jonathan
McMahon's White
Mammoth Black Twig
York Imperial
Maiden's Blush
Missouri Pippin
Northern Spy
Norton's Melon
Ortley
Pewaukee
Primate
Golden Pippin
Red Cheek Pippin
Rome Beauty
Rambo
Red Astrachan
Rhode Island Greening
Rosbury Russet
Salome
Spitzenburg
Tallman's Sweet
Wealthy
Winesap
Transcendant Crab

4. **Self-Fertile Apples.**

Baldwin
Bailey's Sweet
Grime's Golden
Keswick Codlin
Duchess of Oldenburg
Shiawasse
White Pippin
Yellow Newton Pippin

5. **Partially Self-Sterile Apples.**

Ben Davis
Canada Red
Spitzenburg
Wagner

Mann	Whitney's Crab
Rambo	Yellow Transparent

2. **Questions.**
   a. Is it always best to plant two or more varieties together?
   b. What varieties of apples are best to plant together?
   c. What varieties of pears are best to plant together?
   d. What varieties of plums are best to plant together?
   e. What varieties of peaches are best to plant together?
   f. What varieties of cherries are best to plant together?
   g. What varieties of each of the small fruits are best to plant together?
   h. How does the pollen get from anther to stigma?
   i. Is the stigma ever closed? When?
   j. What becomes of the pistil in ripe fruit?
   k. What is the value of pollination?
3. **References.**
   a. Plant Breeding, by Bailey.
   b. Fruit Growing, by Bailey.
   c. Fruit Growing, by Paddock and Whipple.
   d. Oregon Bulletin No. 20.
   e. New York Bulletins Nos. 169, 224, 350.
   f. Lessons with Plants by Osterhout.
   g. Experiments with Plants, by Osterhout.
   h. The American Fruit Culturist, by Thomas.

BUDS AND BRANCHES.

1. Buds.

1. **Buds.**
   a. Study a twig. Fig. 70.
      1. t—terminal bud.
      2. ax—axillary bud.
      3. ls—leaf scars.
      4. tr—leaf traces.
      5. l—lenticel.
      6. rs—ring of scars left by bud scales of preceding season.
      7. Study a twig of a fruit tree.
2. **Buds** are the undeveloped branches or flowers.
   a. Composed of a mass of tiny leaves.
      1. Inside ones are crumpled and compacted.
      2. The outside ones are known as the bud scales with a regular formation and drop off when the bud starts to grow, leaving a leaf scar.

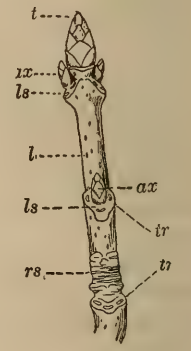


Fig. 70, Winter twig of a maple. (Andrews' Botany)

   b. **Kind of buds.**
      1. Terminal buds are ones that grow at the end of twigs or shoots.
         a. A terminal bud may be either a leaf bud or a flower bud, or both a leaf bud and flower bud.
      2. Axillary buds are the ones that grow in the axil of leaves.
         a. An axillary bud may be a leaf bud, flower bud, or dormant bud.

Exercise 33.

1. **Object:** To locate the buds, scar and leaf traces, etc.
2. **Method:**
   a. Collect several fruit twigs; one year old; two years old; three year old.
   b. Point out the different buds.
   c. Point out the number of leaves on each twig.
   d. Point out the leaf traces.
   e. Point out the leaf scars.
   f. Point out the ring of scars.
   g. Compare the growth, buds, number of leaves of the different twigs.
3. **Note.**
   a. Pull off the bark of the tree and note the little incipient branches which never develop.
   b. What would have been the result if the bark above each incipient branch had been cut?
   c. Study the twigs of the Apple Rosette.

3. **Function of buds.**
   a. Terminal flower buds produce fruit.
   b. Terminal leaf bud continues the growth of its twig or shoot.
   c. Axillary flower bud produces fruit.
   d. Axillary leaf bud continues the growth of a spur which may be a fruit spur or a leaf spur.
   e. Axillary dormant bud may lie inactive for months or even years, then through the injury or destruction of its strongest rivals or some other favorable cause, develops into a branch, as sprouts on stumps.
4. **Growth of buds.**
   a. The tendency of a plant is to grow from its uppermost or terminal buds.
   b. It will be noted that these buds are the strongest because they have had the most air, heat, and light, to develop them.
   c. They grow in the direction that they are pointed.
   d. Pruning may change the direction of growth.
   e. Light will change the natural direction.
5. **Causes of** the difference between fruit-buds and leaf buds.
   a. Leaf-buds are the result of rapid growth and fruit buds of slow growth.
   b. Check the growth by any means and many fruit-buds will be produced.
   c. Check the free flow of the sap and fruit-buds are produced.
   d. Fruit-spurs, produced from leaf-buds, but which, making little growth, become fruit-bearing.
   e. Pruning leaf-buds produces fruitfulness of the tree.
   f. Pruning fruit-buds produces more vigorous growth.
6. **How to tell the fruit buds.**
   a. **Structure of the buds.**
      1. The fruit buds are larger, thicker, rounder, more blunt and more fuzzy than leaf buds.
      2. The fruit buds contain miniature unopened flowers when examined.

b. **Character of spurs.**
   1. The fruit spurs generally remain such and so many of them may be many years old and yet be only a few inches long.
   2. The fruit spurs that produce terminal fruit buds grow crooked.
   3. The fruit spurs that mature fruit one year, produce only leaf buds that year, and make blossom buds the following year.

7. **Location and habits of fruit buds.**
   a. **Apple.**
      1. The fruit buds may be terminal on spurs of one or more year old.
      2. The fruit buds may be terminal on twigs of last year's growth.
      3. The fruit buds may be axillary buds on last year's growth.
      4. The fruit buds contain both flowers and leaves.
      5. The fruit buds are formed in the summer and lie dormant during the winter.
      6. Vigorous growth checks fruitfulness and checking the growth produces fruitfulness.
      7. Fruit bearing on spurs is conductive to the production of annual crops.
      8. Fruit buds grow singly and expand into clusters of flowers with several leaves.
   b. **Pears are same as apples.**
   c. **Quinces.**
      1. The fruit buds are terminal on shoots formed the same year upon new grown wood.
   d. **General of the stone fruit.**
      1. The fruit buds are lateral on twigs, and develop in axil of leaves of the current year's growth and the fruit is borne on one year old wood.
      2. The fruit buds contain flowers; no leaves, or only rudiment of leaves.
   e. **Peach.**
      1. Same as general, except—
      2. The fruit buds are nearer the tips of strong growing twigs.
      3. The fruit buds carry from one to two flowers.
      4. The fruit buds are generally two in a place with leaf buds between.
      5. The fruit buds are formed in summer and lay dormant during winter.
      6. The fruit buds grow in groups in the axil of clusters of three leaves.
   f. **Apricot.**
      1. Same as general, except—
      2. The fruit buds may be terminal on spurs of new growth which are often very short.
      3. Fruit buds grow in the axils of single leaves.
      4. The fruit buds form the same year on new spurs which grow on old wood.
      5. The apricot and peach are almost similar in their fruiting habits.

g. **Plum.**
   1. Same as general, except—
   2. The fruit buds are on spurs of old wood, seldom new.
   3. The fruit buds carry from one to five flowers.

h. **Cherries.**
   1. **Sour cherries.**
      a. Same as general, except—
      b. The fruit bud carries from one to five flowers.
   2. **Sweet cherries.**
      a. Same as general, except—
      b. Generally the short spurs on second year's wood are the fruit bearing part.
      c. Fruit buds may be terminal and carry from one to five flowers.

i. **Prunes same as plums.**

Exercise 34.

1. **Object:** To study fruit buds of the pome and stone fruits.
2. **Method:**
   a. Select a twig of each variety.
   b. Locate the fruit buds of each.
   c. The number of flowers in the fruit bud.
   d. Position of leaves and axillary buds.
   e. Study the scars and bud scales.
3. Compare fruit buds of stone fruit with pome fruit.
4. Describe the growth of the fruit buds, leaf buds, of stone fruit and the pome fruit.

j. **Gooseberries.**
   1. The fruit buds are terminal on spurs of one or more years old.

k. **Currants.**
   1. The fruit buds are either terminal or lateral on spurs of one or more years old.

l. **Raspberries,** blackberries, dewberries, etc.
   1. The fruit buds are either terminal or lateral on lateral summer shoots.

m. **Grapes.**
   1. The fruit buds are lateral on shoots of current season's growth from buds which spring from last year's growth.

n. Select shoots of the berry fruit and study the fruit buds as of stone fruit.

8. **Environments.**

a. Air, light, heat and food supply.

Exercise 35.

1. **Object:** To show the effect of environments on the growth of buds.
2. **Method:**
   a. Compare a compact headed tree with a free growing, open-centered tree.
      1. Amount of air admitted and size of buds.
      2. Amount of light admitted and size of buds.
      3. Amount of heat admitted and size of buds.

2. **Branches.**

1. **Branches** are produced from leaf buds which may be terminal, lateral, or adventitious.
2. Buds are buds only so long as they remain dormant.
3. Lateral branches are of varying lengths, some being so short as to be mistaken for buds.
4. **Kind of branches.**
   a. Fruit spurs are short lateral branches, which usually remain fruit spurs.
   b. Adventitious branches are ones that develop anywhere on the stem or branch except at nodes.
   c. Watersprouts are often produced by heavy winter pruning because more plant food is sent up from the roots than the top can use, resulting in the growth of dormant lateral buds.

Fig. 71, Shows excurrent growth; Pyramidal top. (Andrews' Botany.)

5. **Arrangements of branches.**
   a. Opposite.
   b. Alternate.
   c. Series of rings.
6. **Growth of Branches.**
   a. Heavy pruning of the tops in winter or during dormant period produces wood growth because the plant food taken up by the root in the spring is concentrated into smaller portion of top, and forcing a rapid growth of the parts left.
   b. The strongest shoots or branches are the terminal ones.
   c. If the terminal buds are fruit buds or become injured or pruned, the growth of the branch is produced from a lateral bud, resulting in a zig-zag growth.
7. **Give the functions of the branches.**
8. Collect twigs from different kinds of trees.
   a. Make a drawing of each.
   b. Compare their growth.
   c. Study a cross section.

Exercise 36.

1. **Object:** To determine what buds produce branches.
2. **Method:**
   a. Examine a fruit tree.
   b. Find branches from what buds they grow.
   c. Determine from what buds they grow.
   d. From what year's growth?
   e. Do branches grow better from lateral buds close to end of limb or lower down on limb?
   f. The formation of a flower bud has what effect on the growth of lateral branch?
   g. Examine two-year-old wood to determine what becomes of lateral buds.

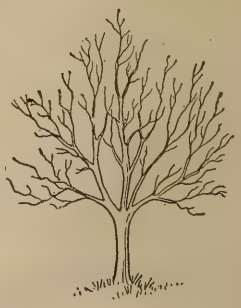


Fig. 72 shows deliquescent growth; Intermediate top. (Andrews' Botany.)

9. **References.**
   a. See references under mixed planting.

PLANTING AN ORCHARD.

1. **Time of planting.**
   a. **Spring planting.**
      1. It is preferable where there is extreme low temperature in winter and where the ground is exposed to extreme dry freezing.
      2. Generally, the trees maintain their dormant condition better in the spring if they are heeled in during the winter.
      3. Plant with the opening of spring before the stored-up plant food is set free is the proper time.
   b. **Fall planting.**
      1. It is practiced in warm sections where the winters are not very cold.
      2. Fall planted trees, in warm sections get an earlier start than in the spring.
      3. The danger of other work or bad weather may delay spring planting.
      4. Fall planting has this objectionable feature that the roots do not take hold of the ground sufficiently to supply enough moisture to maintain a healthy, active circulation of sap which is required to prevent shriveling of the branches during winter's extreme cold and exhaustive evaporation from drying winds.
2. **Selection of trees.**
   a. The selection of trees is one of the most important things and upon the care and judgment in this matter largely depends the kind of an orchard that will be grown.
   b. A vigorous, well grown, one-year-old tree, with a large, strong heavy base having a well developed root system, should be selected.
   c. Trees of this type and age are more satisfactory and profitable in time and suffer less in transplanting, and are much more easily handled than older ones.
   d. The local nurseryman, if perfectly familiar with his business, will understand the needs and demands of his home customers and should grow the varieties best suited to his section of country.
   e. By securing trees at the nearby nursery all danger from damage by long transit and the injurious effects of sunshine and frost are avoided.
   f. Some prefer budded trees to grafted ones, as grafted trees induce crown gall.
   g. Study the different varieties.
      1. Variety best suited for given soil.
      2. Whether vigorous or weak growing kind.
      3. Variety that will properly color on given soil.
      4. Whether upright or spreading in form.
      5. Whether early or late varieties.
      6. Whether good or poor keepers.

3. **Choose varieties** that will pollinate together.
   a. If there are two or more varieties, plant four rows of each variety.
   b. The above arrangement is better and more convenient for harvesting, pruning and spraying.
   c. Any variety occurring in any of the following columns is well pollinated by any one or more varieties in the same column.
   d. Table of early and late pollination.

1. Apples.

Early.	Late.	Late.
Gravenstein.	Arkansas Black.	Ortley.
Oldenburg.	Baldwin.	Red-cheek Pippin.
Red Astrachan.	Ben Davis.	Rome Beauty.
Tetofsky.	Black Twig.	Spitzenberg.
Wealthy.	Gano.	Wagener.
Yellow Transparent.	Grimes Golden.	Willow Twig.
	Jonathan.	Winesap (shy pollen producer).
	McIntosh.	White Winter Pearmain.
	Newton.	Yellow Bellflower.
	Northern Spy.	

2. Pears.

Early.	Late.
Bartlett.	Angouleme.
Clairgeau.	Bosc.
D'Anjou.	Du Comice.
Howell.	Easter Beurre.
Kieffer.	P. Barry.
	Winter Nellis.

   e. Varieties that do best on rich medium mesa soils.
      1. Ben Davis, Gano, Grimes Golden, Jonathan, Rome Beauty, White Winter Pearmain, Winesap, Spitzenberg.
   f. Varieties that do well on heavy soils.
      1. Missouri Pippin, Newtown Pippin, both green and yellow.
   g. Varieties that do well on light soils.
      1. Arkansas Black, Ben Davis, Gano.
   h. Varieties that do well on any soils.
      1. Ben Davis, Gano, Yellow Transparent.
   i. Commercial varieties.
      1. Gano, Grimes Golden, Jonathan, Rome Beauty, Winesap, Newtown Pippin, Spitzenberg and Arkansas Black.
   j. Make a list of the varieties for your section.

4. **Distances for planting.**
   a. A decision as to the proper distance apart to set apple trees varies with different planters.
   b. Some plant 16 to 32 feet, that is, the trees 16 feet apart in rows 32 feet apart.
   c. The object of this method is to obtain a crop from the trees until they begin to interfere with each other, when every alternate tree in the row is cut out, leaving the trees in the entire orchard at a distance of 32 feet each way.
   d. The trees to be cut out should be early-bearing, short-lived varieties.

e. This system has the advantage of more fully utilizing the land for fruit production until the thinning out becomes necessary.
f. Other planters adopt a distance between trees of 24 or 30 feet apart each way, claiming that by the time the trees interfere with each other they will have finished their growth and the orchard will begin to decline.
g. The distance of 30 feet each way is generally used.
   1. It will afford ample space between the rows for growing any crop which requires cultivation, such as corn, beans, potatoes, etc.
   2. It will afford free circulation of air and sunshine, both of which are essential to the growing of well developed and highly colored fruit.
h. **Tabulated distances.**
   1. Standard apples .....30 feet each way
   2. Standard pears .....20 feet each way
   3. Sweet cherries .....30 feet each way
   4. Sour cherries .....20 feet each way
   5. Standard plums, peaches, apricots, nectarines .....16 to 18 feet each way
   6. Quinces, dwarf pears and apples....10 to 12 feet each way
   7. Grapes .....7x10 to 16x16 feet each way
   8. Currants and gooseberries.....4 feet each way
   9. Raspberries and blackberries.....3x5 to 4x7 feet each way
   10. Strawberries in field.....1x3 to 3½ feet apart
   11. Strawberries in garden .....1 to 2 feet apart

5. Methods.

a. **Square Method.**
   1. **Rule:** Multiply the distance in feet between the rows by the distance the trees or plants are apart in the rows, and the product will be the number of square feet for each one, which, divided into the number of feet in an acre (43,560) will give the number for the acre.
   2. It is the easiest laid out and cultivated and permits of gradual thinning out of fillers if they are needed, but the land is not evenly distributed to each tree.
   3. Fig. 73 shows the square method using thirty feet as the distance that the trees are to be apart.
      a. The dots indicate the permanent, primary, secondary trees.

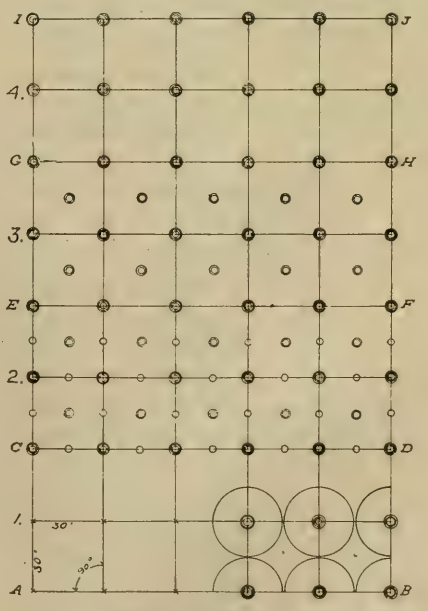


Fig. 73, Shows the square method.

b. No. 1 shows that permanent trees are set in the corner of the square.
c. No. 2 shows where the primary and secondary fillers are set.
d. No. 3 shows that the secondary fillers are removed.
e. No. 4 shows that the primary fillers are also removed.

4. In this, the trees are set at the corners of a square, making the rows an equal distance in both directions.

Exercise 37.

1. **Object:** To lay out an orchard by the square method.
2. **Method:**
   a. Establish a line (BJ) along one side of the field.
   b. Locate where trees are to be set.
      1. Use a No. 10 or 12 gauge galvanized wire as long as the field; have washers soldered on wire, use tags on wire, or make links in wire at distances that the trees are to be set apart.
      2. Place the wire on any line and drive a peg where each tree is to be set as indicated by the washers, tags, or links.
   c. Place wire on line (BJ) and drive pegs where trees are to be set.
   d. Establish the line (AB).
      1. Use a carpenter's square which has sides in the ratio of 3, 4 and 5.
      2. Place the square at the corner (B); one side will be on the line (BJ) and another will mark the line (AB); then locate the corner (A) by sighting from the corner (B).
   e. Establish line (A1) in the same manner as line (AB) and locate the trees by using the wire.
   f. Establish rows across the field.
      1. Stretch the wire from "A" to "B" and drive a peg where each tree is to be set.
      2. Locate other tree rows by using the corresponding stakes in lines (A1 and BJ).
   g. When this is done by using the planting board, the holes may be dug and the trees planted, and the rows kept straight.
   h. Should the field be large, run a base cross rows midway of the field, or sub-base lines to help out.
   i. Should the land be cut up by a steep draw running through it, draw the wire tight just the same and drop small stone from the link in the wire.
   j. Where it strikes the ground drive a peg to locate the tree.

b. **Hexagonal or triangle method.**

1. **Rule:** Divide the number required to the acre "square method" by the decimal .866; or calculate the number by the "square method" and add 15 per cent to get the number of plants required to the acre by this method.
2. Fig. 74 shows the hexagonal system, using 30 feet as the distance that the trees are to be apart.
   a. Dots indicate permanent and primary trees.
   b. No. 1 shows where permanent trees are set.
   c. No. 2 shows where primary fillers are set.
   d. No. 3 shows that primary fillers are removed.

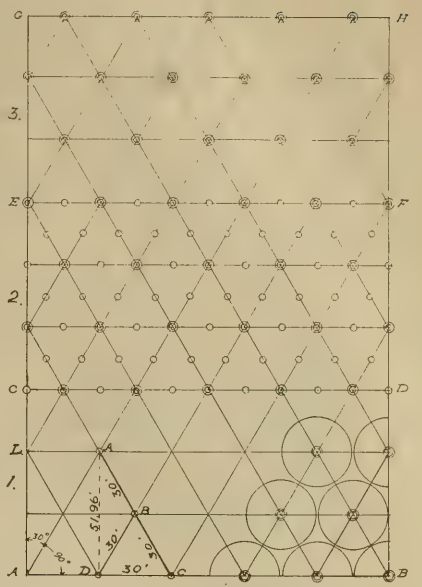


Fig. 74, Shows the Hexagonal System.

3. In this, the trees are more evenly distributed over the surface which allows of more permanent trees being planted per acre; 15 per cent more than the square method and yet the trees are the same distance apart as in the square method.
4. This in itself is worthy of considering.
5. The triangular system is not so easily cultivated, especially at the ends of the rows and in the corners.

Exercise 38.

1. **Object:** To lay out an orchard by the hexagonal method.
2. **Method:**
   a. Establish the lines BH, AB, and AG; as in the square method.
   b. Use wire, as in square method.
   c. The trees on lines AG and BH are farther apart than on the lines AB and GH.
   d. To find the distance that the trees are apart in lines AG and BH.
      1. In triangle ADC, the side DC is the distance that the trees are to be apart and the side AC is double the distance that the trees are apart.
      2. Extract the square root of the difference between the square of AC and the square of DC and the answer is the distance AD which is the same as AL.
      3. The distance AL may be found by fastening one end of the wire at D, then the second mark on the wire will meet the line AG at a point L.

4. AL is the distance that the trees are to be apart on lines AG and BH.
5. Mark off the distance AL along the lines AG and BH and drive pegs where the trees are to be set.

e. The first row of trees will be the line DL, and the second row will start at "C."

f. After a few rows are pegged off, a base row may be run diagonally from the corner "A."

c. **Quincunx Method.**

1. It takes one-half more trees to plant an acre by the Quincunx method than the square method.
2. This system plants in triangles rather than in squares.
3. Usually the fifth tree is set in the center of a square.

d. **Problems.**

1. Work out the number of permanent trees required to plant an acre by each method, from 15x15 to 40x40 feet.
2. Work out the number of fillers required to plant an acre by each method.
3. Tabulate the result.

Exercise 39.

1. **Object:** To determine how to plant several varieties.
2. **Method:**
   a. Make selections of 2, 3, 4, 5, 6 or 8 varieties.
   b. Use some of the selections as fillers.
   c. Use 14, 15, 16½ feet as distance.
   d. Determine how to set trees in order that any variety, or varieties, may be cut out after 8 to 10 years.
   e. Note: The commercial value of fruit in ten years may be different than at present.

6. **Transplanting.**

a. **Preparing the land at time of planting.**

1. The land should be in as good condition as it is possible to make it.
2. There should be a deep, rich bed of mellow soil and well drained for the tree rows.
3. The soil had better be prepared in the late fall in order that it will be ready for early spring planting.
4. The method of plowing the land in the fall and leaving it lay up loose through the winter is a good one because the effect of the rain, snow and freezing will leave the soil in better condition.
5. Never use manure in contact with the roots but if soil is poor use nitrate of soda.

b. **Protect the roots.**

1. Keep the roots covered with straw, burlap, or canvas and on reaching home heel in, wetting and packing the ground thoroughly.
2. Take only a few at a time out of the ground at planting time.

3. Keeping the trees in a barrel or a tub of water in the field while planting, insures against needless exposure.

c. **Preparing the tree for planting.**

1. All mutilated or dead roots should be removed and in cutting away roots it should be the aim to make the cut in such a manner that a smooth, clean surface is left.
2. When the tree is placed in position, the smooth cuts should come in contact with the moist soil either at the sides or bottom of the hole.
3. Many of the fruit-bearing plants as the apple, pear, peach, plum, and grape will stand quite a severe root pruning.

Fig 75, Shows how the roots are cut at digging time.

Fig. 76 — Shows the relation of the roots to the top after the roots are pruned.

7. **Digging the hole.** Fig. 77.

a. No. 1 shows a board four feet by four inches with notches on side.

b. No. 2 shows the board in position after the hole is dug.

c. No. 3 shows another planting board four feet by four inches hinged in the center.

1. The end (A) is to be raised after the board is placed, in order to dig the hole, without moving the board from position.

d. No. 4 shows the end (A) in position after the hole is dug.

e. Make the hole large enough to admit the roots without cramping or bending.

f. The above holes show how the bottoms should be in order to give the roots plenty of room.

8. **Setting the tree.**

a. Cover the roots with fine soil which should be carefully worked among them.

b. Pour in some water when the hole is partially filled; if in an irrigated district run in the water from the ditch.

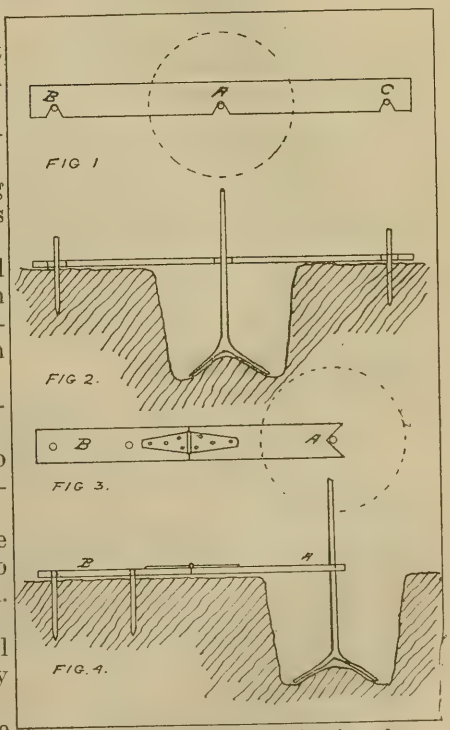


Fig. 77.—Shows two planting boards.

c. The ground should be firmly and solidly packed over all parts of the roots to prevent dry air and frost entering and destroying them.
d. Fill the holes with the surrounding surface after the fresh earth settles and leave a dry mulch of earth on top.
e. It is best to set the trees a little deeper than when in the nursery, and leaning slightly against the prevailing wind.
f. By this position the tops will soon shade and protect the bodies from the intense heat of the summer sun which is likely to cause sun scald.
g. Large trees should be staked and tied.

Exercise 40.

1. **Object:** To transplant seedlings by "tin can" method.
2. **Method:**
   a. Get some small, thrifty seedlings about 6 to 8 inches high, growing in nursery beds or in the open, if possible.
   b. Dig them up carefully, allowing as much earth as possible to remain clinging to the roots.
   c. Get some tin cans, such as tomato cans, in which to plant the seedlings.
   d. Across the bottom of the cans make two cuts at right angles to provide drainage, and allow the roots of the seedlings to escape.
   e. Place the seedlings in the cans and fill in rich earth until they are firmly planted in the cans.
   f. They may now be kept in the schoolroom windows if the cans are set in a trough or tray so that the little trees can be watered and tended like ordinary plants.
   g. In the spring set out cans and all in places where it is desired to plant the trees.
   h. The cans will soon rust away and the little trees will continue to grow unchecked.
3. Note: If desired, seeds can be planted in the cans and the trees grown in this way instead of transplanting the seedlings to the cans.

9. **Study of Bush Fruits.**
   a. References.
      1. Bush Fruits by F. W. Card.
      2. Washington Bulletins Nos. 18, 25, 26.
      3. U. S. Dept. Bulletins Nos. 154, 198, 213.
10. **References.**
   a. Fruit Growing by Bailey.
   b. Fruit Growing by Paddock and Whipple.
   c. American Horticulture Manual, 2 Vols. by Budd and Hansen.
   d. The American Fruit Culturist by Thomas.
   e. Popular Fruit Growing by Green.
   f. Nursery Book by Bailey.
   g. Lessons with Plants by Bailey.
   h. Experiments with Plants by Osterhout.
   i. Montana Bulletins Nos. 44, 77.
   j. Oregon Bulletins Nos. 20, 111.
   k. Washington Bulletins Nos. 14, 24.
   l. U. S. Dept. Bulletins Nos. 113, 181, 482.

PRUNING.

1. **Pruning and training** are requisites in the successful management of an orchard.
2. **The objects to be attained are:**
   a. Symmetrical and evenly balanced heads.
   b. To admit sunlight and free circulation of air into all parts of the tree tops to give color and quality to the fruit.
   c. To maintain sufficient density of foliage to protect the trunks and branches from the direct intense heat of the sun's rays, which is likely to scald and injure trees.
   d. To remove dead, dying, diseased, or broken branches.
   e. To reduce the annual growth for the purpose of correcting the bad habits of the plant.
   f. To remove branches in order to prevent the breaking or disfiguring of the tree in later years.
   g. To reduce the annual growth in order to reduce the crop in proportion to the capacity of the tree.
   h. To protect trees against storms.
   i. To facilitate tillage, spraying, thinning and harvesting.
3. Pruning accelerates or augments growth in plants because the remaining parts receive more plant food.
4. Tends to develop the lateral and the dormant buds.
5. **Rejuvenation of trees.**
   a. Old, weak, diseased, or winter-killed trees are rejuvenated by heavy pruning of the tops, which induces the trees to throw out strong new shoots.
   b. Fruit trees which have reached a great age resulting in producing undersized fruit may be headed back as far as two-thirds of the length of the limbs, or even more.
   c. All heading-back should be to such an extent as to completely remove the injured branches.
   d. If this is not practiced, the injured branches may start to grow in the spring and then die later in the season.
   e. Injured trees should be thoroughly headed-back.
6. **Methods of pruning.**
   a. **Heading-out.**
      1. Study the location of fruit-buds.
      2. Cutting limbs back just above an outside bud or lateral branches.
      3. Causes spreading tops.
         a. The natural form of a tree.
         b. One factor used to develop a spreading head is to prune the limb to an outer bud.
      4. This causes the new growth to point outward.
      5. This may be increased still farther by leaving a stub about two inches above the bud, cutting the stub away later in the season.
      6. This causes the new growth to grow more nearly at right angles with the parent limb.
      7. The more upright the tree grows, the more heading-out ought to be practiced.
      8. Study where the fruit spurs are located before pruning.

b. **Heading-in.**

1. Study the location of fruit buds.
2. Cutting limbs back just above an inside bud.
3. Causes upright tops.
   a. Heading-in causes the growth to point inward.
   b. Heading-in tends to thicken the crowns of the trees, making them have dense tops.
4. Young trees are generally headed-in to make thick, stocky branches.
5. Heading-in must be lessened as the tree ages.
6. The more spreading the tree grows, the more heading-in ought to be practiced.

c. **Heading-back.**

1. It may be combined with heading-in or heading-out.
2. Heavy cutting back of the top-center limbs.
3. Tends to make thick and stocky branches.
4. Points to determine.
   a. Thick and round-headed tops, or,
   b. Free-growing and open-centered tops.
   c. Nearness the trees are to each other.
   d. Type of trees.
      1. Branches grow upright or spreading.
      2. Branches that grow upright at first, then grow spreading after the tree begins to bear fruit.
5. Never prune a tree until you know why you are pruning it.
6. A tree having upright growth, as some varieties of apples, and most pear trees, should be headed-back when young, so that the lateral buds will develop and thus make the head of the tree broader.
7. Begin to prune when the trees are young and prune a little each year.
8. The heading-back of old trees tends to develop water-sprouts out of the fruit spurs and fruit twigs.
9. These water-sprouts, then, must be cut off and results in the loss of the fruit which should have been grown on the spurs.
10. Always cut out the large limbs of a tree before you cut the smaller ones if the top of the tree is too thick.
11. We are apt to prune off the necessary limbs which we can conveniently get at and leave a mass of smaller limbs in the top.
12. Study the tree as a unit, remembering that each variety of trees needs its own kind of pruning.
13. The formation of a good shape and framework on the tree, rather than to produce fruit bearing, is the first principle.

14. The load of fruit is carried nearer the trunk on main structural branches which are larger in proportion to their length than lateral branches, and better able to carry a load of fruit which the tree may develop.

Fig. 78. — Shows where to cut stem at time of of planting.

7. **Pruning the stem.**
   a. Cut back the top from twelve to eighteen inches above the ground.
   b. Leave the buds so arranged that three or five shoots will develop.
   c. The orchard consists of a lot of stubs sticking out of the ground not over eighteen inches high.
   d. During the season, these stubs will develop shoots from each bud.
   e. Allow all the shoots to grow until early in July; if the tree stems are slender let grow until the first of August, then remove the surplus shoots.
8. **Main branches.**
   a. Three to five branches are considered the ideal number.
   b. More may be left upon some varieties, particularly those which are strong growers and upon trees which have a well developed root system at planting time.
   c. If the roots have been badly mutilated in removing the tree from the nursery, it will be safer to reduce the branches to three rather than to maintain a larger number.

Fig. 79.—Shows how tops are shaped and scaffold limbs arranged. (Paddock and Whipple.)

   d. **Study Fig. 79.**
      1. A—shows tree at end of first season's growth.
      2. B—shows the same tree headed-back.
      3. C—shows the same tree at end of second season's growth.
      4. D—shows the same tree headed-back, but branches too close.

e. Pruning should be directed toward retaining the above shape, cutting back excessive growths and thinning and renewing the bearing wood and to develop fruit spurs.

f. **Arrangement of branches.**

1. Disposed of equal distances about the main stem or axis of the plant in order that the development will be symmetrical.
2. Branches should be disposed at some distance from one another.
   a. The second branch should be at an angle of 33° or 45° from the first and several inches above it.
   b. The third branch should be at an angle of 66° or 90° from the first and several inches above the second branch.
   c. The other branches should be arranged in the same proportion.
3. The above arrangement forms the best union between branch and body; and is less liable to injury from heavy snows and winds.

9. **Forming the top.**

a. **Merits of low-headed top.**

1. Low limbs may be trained upright.
2. Hold their weight and position better.
3. It is easier to spray, prune and gather the fruit.
4. Symmetry and solidity are better formed.
5. Less danger from high winds.
6. Protection against sun scald.

b. The horizontal diameter of the top should be double the height of the top, which is true with peach trees and many varieties of apple trees.

c. The top should be free-growing, open-headed, in order that the fruit may receive sufficient air, heat, and light.

d. The lowest scaffold limb may be only a few inches above the ground, depending on the number of limbs.

e. In forming the head, care should be taken to have the framework branches disposed at different heights along the body of the tree, several inches apart, and distributed as evenly as possible around the body as a central axis. Fig. 80.

Fig. 80.— Shows how the branches should be arranged and where to prune one year from planting.

f. **End of the first season's growth.**

1. Consider each shoot as a separate tree.
2. Select from three to five of the best shoots to form the head of the tree when the tree is pruned.
3. Care should be taken that no two spring out opposite one another. Fig. 80.
4. Cut back to an outside bud, the shoots 1, 2, 3, from one-third to one-half of the last year's growth. Fig. 81.

5. Leave the buds so arranged that the first year's shoot will subdivide; as in Fig. 81.
6. To secure a well formed and nicely balanced head, these shoots must be frequently watched and any which grow too fast, pinch them back, to maintain an equality.
7. Those left should be the strongest shoots, at equal distances apart around the stem, and should tend to an outward growth to spread and make an open head.
8. Remember that the leaves are to the plant what lungs are to animals.
9. Sometimes trees are planted that have two or more pruned limbs, which subdivide and several shoots are grown on each limb at the end of the first season's growth. Fig. 82.

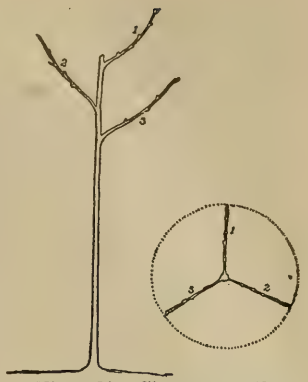


Fig. 81.—Shows a three branch tree at the end of the first season's growth.

Fig. 82.—Shows the branches subdivided.

g. **End of second season's growth.**

1. Study how the top is formed and pruned in Fig. 83.
2. The tree may be spread or contracted, by cutting to a bud which points inward or outward.
3. Prune second year's growth back from 1/3 to 1/2 of their original length in the winter or spring of the third year.
4. When the growth is eight inches or less, heading-back should be less.
5. This will leave a properly shaped frame upon which the crown is to be grown, leaving the most central one as a leader, which should be pruned from four to six inches longer than the others.
6. What may seem an open head when young may prove, when the trees are older, to be too dense and crowded.

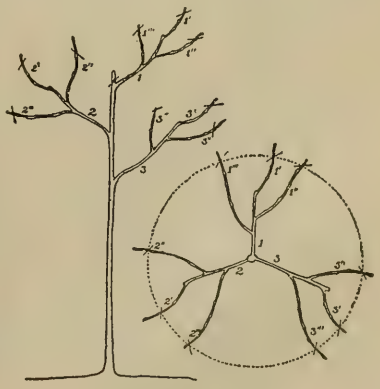


Fig. 83.—Shows plan of top after two years' growth.

h. **End of the third season's growth.**

1. Select from two to three limbs for each branch of the frame, removing the superfluous, broken, or crossed limbs.
2. Cut third year's growth back from one-third to one-half of their length in the spring of the fourth year.

3. The leader should be maintained, and the top carefully formed in order to prevent heavy growth in undesirable places.
4. The next year or two, pruning should only differ from the last described, in that the shortening of limbs should be less each year and the crown thinned out more as years pass.
5. More attention should be given the location of the fruit spurs after the third year.
6. In all pruning of young trees care should be taken that no two limbs should emerge opposite one another thus forming a bad crotch.
7. Cut out every limb that forms a closed crotch.
8. Cut every limb to a bud so that no dead stubs will be left.

i. **Forms of top.**

1. The pyramidal form is the opposite of the vase form in that the main stock or leading shoot of the tree is allowed to maintain its upright growth and the side branches are shortened back so as to produce the form of a pyramid, as shown in Fig. 71.
2. Intermediate form is between the vase and the pyramid, which gives a round, symmetrical shape to the tree and sufficiently open to allow free circulation of air and sunlight, as shown in Fig. 72.
3. The vase or goblet form, which is obtained by cutting out the central stock or leader and training by a system of pruning into the shape as shown in Fig. 84.
4. The half-vase form with a leader exposes almost all the fruit and is a more profitable shape, easier to support and more natural.

j. **Balance top.**

1. Study the tree with the idea of pruning it and leaving it with a well balanced head.
2. Do not let one side, without it be the side toward the wind, be heavier than another side.
3. Do not cut off a single limb without there is a good reason for it.
4. Endeavor to prune and shape the tree so that there will not be long leaders formed.
5. This is accomplished, not by heading-in, but by cutting back the leaders to

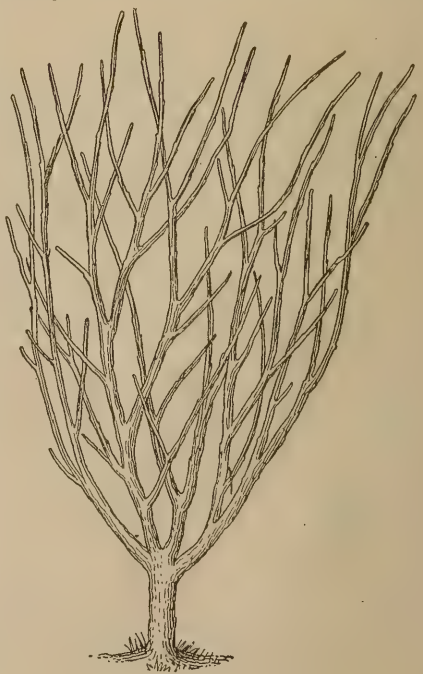


Fig. 84.—Vase form.

three or more laterals, thus making two or three leaders each out of the three or more laterals.

6. These lateral leaders, in turn, should be treated the same way, some will have to be thinned out, however.
7. By following this method, strong, sturdy main branches may be formed, giving more room for fruit to be borne upon, and also less chance for the fruit to be whipped off by the wind.
8. Don't forget to make a clean cut when severing a limb from the tree.
9. Cover the cut over with white lead which has been thinned with oil.

10. **Method of root pruning** after several years of growth.
    a. The operation is performed by digging out a circular trench at a distance of from 3 to 6 feet from the stem, according to the size and age of the tree, and from 2 to 4 feet in depth, cutting all the roots that may be encountered or can be reached.
    b. If but few strong roots are met with, and if it appears evident that the strong taproots exist, the soil should be undermined with a sharp mattock, severing all the strong roots that can be reached; the soil is then returned being well firmed as the trench is filled, and the process is completed.
    c. **Effects of root pruning.**
        1. **Stimulation of fruit buds.**
            a. When a tree has attained to a fruit bearing size and shows no indication of fruiting, but continues to maintain a vigorous growth of branches and is evidently barren as the result of excessive luxuriance, judicious root pruning will have the effect of encouraging formation of fruit buds.
            b. Trees in this condition, if root pruned about the middle of July, will receive a check to growth which will cause formation of fruiting buds during the fall and show a flowering disposition the following spring.

11. **Summer pruning.**
    a. It should be done the last of June or early July.
    b. It may encourage the formation of fruit buds on tardy bearing varieties but it may have the opposite effect unless it is done at the proper time.
    c. All watersprouts, cross limbs, and unnecessary limbs should be removed.
    d. Young trees that are making vigorous growths may be headed back causing side branches to develop and making a round-shaped top.
    e. Such varieties as Spitzenberg and Yellow Newtown, that are slow to come into bearing, may be headed-back when they are five or six years old.

12. **References.**
    a. See references under orchard planting.

PRUNING THE DIFFERENT KINDS OF FRUIT TREES.

1. **General principles.** **1. Apples.**
   a. Attention must be given not only to the height and formation of the head, but to the removal of wood as well.
   b. The apple bears its fruit on spurs which are themselves developed from wood two or more years of age.
   c. The removal of wood which carries fruit spurs reduces the crop that the tree is capable of bearing.
   d. Pruning lessens the annual growth and forces the energy of the plant into the fruit.
   e. Prolific varieties should be heavily pruned.
2. **Pruning different varieties.**
   a. Because of their slim twigs, the Limber Twig, Willow Twig, Geneton, Rome Beauty and Yellow Bellflower have to be headed back more than most other varieties, because they have a tendency to make long limbs without branching, or with few branches.
   b. Heading-in a bearing fruit tree produces an excessive growth of new wood, which is in the wrong place, causing the tree to become dense, shading the fruit, and producing an inferior quality.
   c. The fruit spurs, when the tree is headed-back, as well as the fruit twigs, are apt to spring into growth and thus develop water sprouts, which next year have to be cut off.
   d. The Stayman Winesap, King of Tompkin's County, Spitzenberg and Red Cheek Pippin must frequently be headed-in more severely than the average tree.
   e. **Upright growth.**
      1. King of Tompkin's County, Northern Spy, Rome Beauty, R.

Fig. 85.—Shows a Rhode Island Greening of two seasons' growth.

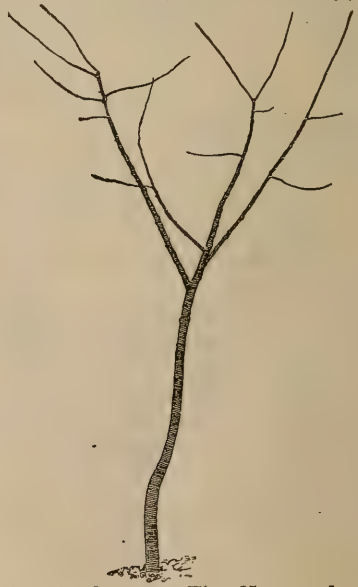


Fig. 86.—Same as Fig. 85 pruned.

I. Greening, Spitzenberg, Wagner, Grimes Golden, York Imperial, Newtown Pippin, Northwest Greening, Yellow Bellflower, Gano, Tolman's Sweet, Wealthy, Wolf River, Yellow Transparent, Red Astrachan, Red June, McIntosh Red, Delicious, Winter Banana, Red Cheek Pippin, sweet cherries and some plums.

2. These frequently require heading-out to spread them.

Fig. 87.—Same as Fig. 86 having four seasons' growth.

Fig. 88.—Same as Fig. 87 pruned. (Cuts 85, 86, 87, 88, from Pruning Book, by Bailey.)

3. **Questions.**
   a. How are the above trees pruned to make spreading tops?
   b. Do they appear to have a heavy growth?
   c. Have they a well-balanced top?
   d. Are the above trees pruned according to the rules of pruning for heading-out?
4. Study the White Pearman, a good type of upright growth.
   a. It is a strong grower.
   b. Does not bear heavy on young spurs.
   c. Fruit spurs are distributed along the larger limbs.
   d. Some varieties do not need heavy pruning.

Fig. 89.—Shows a White Pearmain type of growth.—(Paddock and Whipple.)

5. Summer pruning incites fruitfulness, but not always satisfactory.
6. Unfruitful varieties may be forced to bear by planting on light soil.

f. **Spreading growth.**

1. Jonathan, Limber Twig, Willow Twig, Geneton, etc.
2. Some which are not so bad are the Maiden Blush, Fameuse, Stayman Winesap, Gravenstein, Hyde's King, Alexander, King David, Arkansas Black and sour cherries.
3. May require heading-in to compact their tops.
4. Study the Jonathan, a good type of growth.
   a. Some varieties, as Winesap and Missouri Pippin are prolific growers and require severe heading-back to prevent spindling tops.
   b. The stocky limbs are better to bear fruit buds than the spindling ones.
   c. Varieties that bloom heavily but set very little fruit, should be treated as overbears and heavily prune during dormant season.

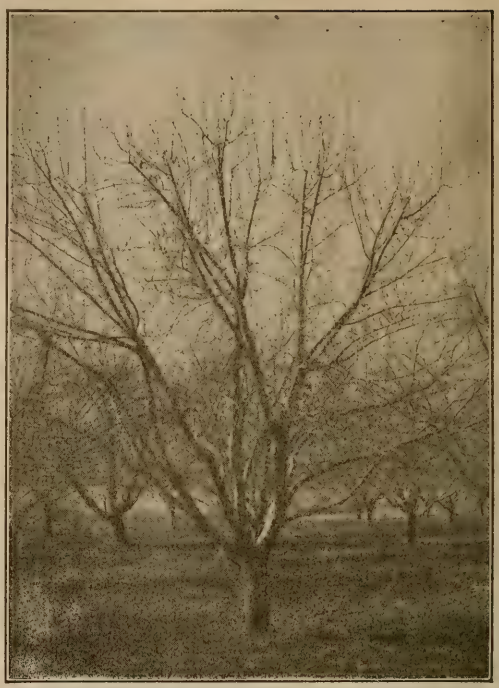


Fig. 90.—Shows Jonathan well headed-in. (Paddock and Whipple.)

g. Compare the Jonathan with the White Pearmain.

3. **Annual and biennial crops.**
   a. Judicious pruning, as has been pointed out, not only facilitates the work of cultivation, and spraying, but at the same time determines to a very considerable extent the fruiting habits of the tree.
   b. The quantity of bearing wood which a tree carries can be modified by pruning so that it will be practically impossible for the top to retain more fruit in any given season than the roots are capable of supplying with a proper amount of nourishment.
   c. Orchardists in general are coming to believe that the reason for the biennial crop in many orchards is due to the fact that during the crop year the trees are allowed to overbear and that their vitality is therefore so much reduced that it is impossible for fruit buds to set a satisfactory crop the succeeding year.
   d. The thinning of the fruit, with the result that a crop is borne each year, has convinced practical growers that over-bearing is the cause of the biennial fruit production.

2. Pear.

1. **General principles.**
   a. What has been said of the apple applies well to the pear.
   b. Mature pear trees need little pruning.
   c. Fruit bearing of the pear is practically the same as the apple.
   d. With proper training there is no reason why the pear tree may not be grown with a moderately broad and low head.
   e. The forming of the tree belongs to the province of pruning the young tree; but a little judicious heading-back practiced on the old tree, taking care to cut to outside buds or branches, will improve on an undesirable form.
   f. When it becomes necessary to head-back the large pear trees, always cut to side limbs and do not make the mistake of choosing an "off year" to do this severe pruning; a heavy crop tends to check rampant growth encouraged by vigorous pruning.
   g. The practice of the most successful growers is to cut the tree back each year and remove some of the new wood that may have been forced by the last pruning.

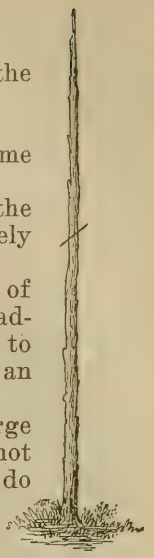


Fig. 91.—Shows where to cut back at time of planting.

   h. The main object of pruning the mature tree should be to thin the fruit and thus improve the quality, as well as to encourage more regular bearing.
2. **Pruning the stem.**
   a. Cut back the young tree as soon as it has been planted to the height from 12 to 18 inches.
   b. The cutting back will cause several of the upper buds to break and grow.
3. **Main branches.**
   a. In forming the head of the pear, however, more branches may be left than in the case of the apple.
   b. While three is given as the ideal number for the apple, as many as four to eight may be retained by a well-grown pear tree.
   c. These should be distributed about the body so as to give practically an equal space between them, and, if possible, they should stand at different heights upon the main stem.
   d. The number of branches to be left upon any particular tree must, however, be de-

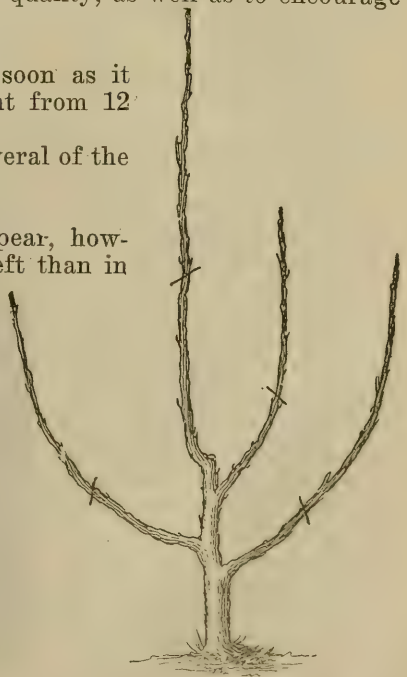


Fig. 92.—Shows a two-year-old pear tree. The lines show where to cut back at time of pruning.

termined by the condition of the roots.

e. The strongest shoots should be left at equal distances apart around the stem and should tend obliquely outward so as to spread and make an open head.

4. **Forming the top.**

a. A low-headed pear tree is quite as desirable as a low-headed apple tree.

b. As the tree grows older it will be found that the original growth of the annual shoots will reduce themselves in many cases to 6 or 8 inches in length.

c. This is due to the fact that the energy of the roots are distributed through a large number of branches, rather than to a few.

d. By adhering to the following system of pruning a symmetrical, broad-headed tree can be secured, and as fruit bearing increases the framework branches will tend to become more and more drooping.

e. The plan of pruning for the first four years should be in cutting back one-half of the last year's growth.

f. The orchardist should keep clearly in mind the form of a tree that is desired; for what seems to be an open head when the tree is young may prove to be too dense and crowded when older.

g. The branches should not be too close together.

h. The upright growing varieties should be headed-out.

i. The slender, straggling growth should be headed-in.

j. All pruning and training should be done when the tree is young.

k. Each branch should, at the close of the first season, be treated as though it were a separate plant, and the number of shoots which it has developed be reduced to three or more, and these in turn shortened to at least one-half of last year's growth.

l. This operation should be repeated from year to year until the tree comes into full bearing, when less shortening will be required.

Fig. 93.—Shows a top-grafted pear tree.—(Paddock and Whipple.)

5. Forms of tops.
   a. Fig. 84.
   b. The vase form or some modification of it has been found to be best suited for the pear tree.
6. Fig. 93 shows top grafted tree.
   a. The best time for grafting is just as the buds are beginning to swell.
   b. It shows a two-year-old top grafted on the small limbs.
   c. The larger lower limbs were removed later.
7. It is well known that orchard trees in general, tend to make their greatest growth near the extremity of the heading branches.
8. The leaders are the strongest growers and it is frequently a difficult task to stimulate lateral branches to grow sufficiently to preserve a symmetrical development in the tree.
9. The manner of cutting back the annual growth on the various parts of the tree must be carefully studied in order to preserve the symmetrical development desired.
10. Heavy pruning in the dormant season will stop the shedding or thinning of the blooms or the young fruit as there is less shedding from trees that bear good crops.

3. Quince.

1. **General principles.**
   a. Young quince trees generally receive no training until planted.
   b. The flowers are co-terminal, borne on this spring's new wood.
   c. Heading-in necessarily thins the fruit.
2. **Pruning the stem.**
   a. It should be cut back near to the ground and a single upright stem allowed to grow.
   b. Severe pruning will aid in securing a good shaped tree.
3. **Main branches.**
   a. A distinct trunk is generally preferred instead of a bush form.
   b. The main trunk should divide into several branches a few feet above the ground, which should subdivide, etc.
4. **Forming the top.**
   a. Almost like the peach.
   b. Among the fruit trees herein considered, the quince has a fruit bearing habit peculiar to itself.
   c. With the advance of spring the dormant buds on the one-year-old wood push out leafy shoots from three to four inches in length and these are terminated by a single flower.
   d. While both axillary and terminal buds produce these flower-bearing shoots, the stronger flowers come from the axillary buds on the last half of the annual growth; terminal buds more frequently give rise to branches or weak flower-bearing shoots.
   e. While with some varieties the plant assumes a tree-form quite readily, others are, at their best, only a bush.
   f. A course of severe pruning for the young tree, however, will aid the grower in securing a desirable shaped tree.
   g. When the tree has reached a bearing age it should be pruned annually by thinning out the new wood and clipping the remaining back to about two-thirds of its legnth.
   h. With proper pruning, the quince should produce annual growths from twelve to twenty-four inches in length.

4. Peach.

1. **General principles.**
   a. The peach is a stronger and more rapid grower than the apple or the pear.
   b. Yearling peach trees are considered more satisfactory by orchardists than older trees.
   c. These young plants are usually reduced to a single stem or whip at planting time.
   d. The head being formed from the shoots which develop along the body of the tree during the first year of its growth.
   e. It is an easy matter to go over the newly planted tree and rub off such shoots as are not desired.
   f. The peach suffers greatly from neglect and responds readily to careful treatment.

Fig. 94 — Peach tree from the nursery.

2. **Pruning the stem.**
   a. Practically the same rule that holds for pruning the stems of the apple and the pear is adhered to in pruning the stem of the peach. Fig. 95.
   b. Fig. 96 shows a well pruned tree the second season after it was planted.
   c Two-year-old tree pruned for shape rather than fruit.
   d. It is necessary to prune severely and possibly to outside buds or branches to secure a top well spread and the fruit wood near the ground.
   e. The pruner should constantly keep before him an ideal form for peach tree.

Fig. 95, Shows tree pruned ready to plant.

3. **Main branches.**
   a. See apple and pear.
4. **Forming of the tops.**
   a. Ordinarily it will be found most satisfactory to prune the peach so as to make a broad, round-headed tree.
   b. The fruit is always borne on the outside buds or upon the new wood of the tree.
   c. The peach tree needs more heading-back and continual pruning than any other fruit tree.
   d. Study the location of buds before pruning.
   e. There is a strong tendency in the terminal buds to push upward and outward, at the expense of the lateral shoots, which soon die.
   f. It leaves the tree in time with long bare poles, with only tufts of leaves at their extremities.
   g. It is necessary to head-back each year, in order to furnish a continued supply of young wood, evenly distributed throughout the top.
   h. At the close of winter or early spring, cut off about four-fifths of last year's growth.

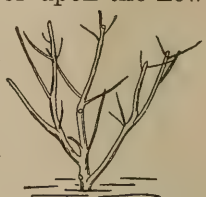


Fig. 96, Low headed tree. Two- and Whipple.) pruned. (Paddock year-old, well

i. This will thin out the fruit buds by one-third or one-half, but the fruit will be so much larger and of finer quality.
j. The division between the one-year-old growth and two-year-old growth is marked by the color of the bark and leaf scars.
l. The annual growth should be at least 18 inches.

5. **Freezing and frost.**
a. It frequently happens that the freezes are severe enough to reduce the annual growth as much as it is desirable to reduce it by pruning, and had the pruning been done before the freezing occurred, there might have been an entire loss of the peach crop.
b. When pruning is delayed until all danger of freezing is past, the pruning can be gauged so as to reduce the fruit bearing wood in proportion to the capacity of the tree.
c. The peach bears singly, rather than upon fruit spurs, as in the case with the apple and pear.
d. For this reason, therefore, the heading-back of the peach trees plays an important part in thinning the crop.
e. Winter killed peach trees may be rejuvenated by cutting back.
f. Clipping back and thinning should be done after the danger of frost is past.
g. Where the injury to the new, and even old growth, is severe, the importance of this cannot be too strongly urged, even if there be but a few live buds left upon the tree and the smaller twigs and limbs be entirely killed.
h. It is better to head them back, than to allow them to exhaust themselves in the endeavor to develop a crop and at the same time make a new growth.
i. If the fruit bud is killed, the pistil turns black or brown; if alive, the pistil is green.

Fig. 97, First year's growth, fall of 1901, low-headed.

Fig. 98, Same as Fig. 97. Properly pruned in March, 1902.

6. The following cuts will illustrate the growth and method of pruning the peach tree for several years.
(The cuts marked W.R.B. are from Maryland Experiment Station.)
a. **The end of the first year's growth.**
1. How did the tree in Fig. 97 look when planted?
2. The stem after it is planted is cut back to about one foot in

Fig. 99, Same as Fig. 98. Two years old, March, 1903.

Fig. 100, Same as Fig. 99. Properly pruned, March, 1903.

length and is allowed to divide into three or five branches during the next season's growth.

3. The same heading-back and multiplication of the branches takes place the next year.

b. **The end of the second year's growth.**

1. 3 to 5 branches should be left to form the framework of the tree, and the others cut off close to the trunk.
2. The limbs retained should be distributed around the trunk, each pointing in different directions.
3. About three-fourths of the length of last year's growth is cut off and the cut is made just above a side limb.
4. Note how the top has grown in one year.
5. Compare Fig. 99 and Fig. 97.
6. Plenty of fruiting wood left; good framework for a productive tree.
7. It will broaden out a little more, if properly pruned in the top.

Fig. 101, Shows a peach tree two years old before pruning. (Paddock and Whipple.)

Fig. 102, Shows the same as Fig. 101 properly pruned and headed-back. (Paddock and Whipple.)

8. Study how Fig. 101 was properly pruned and headed-back.
9. How are the leaders pruned?
10. Is width of top greater than the height?

c. **The end of third year's growth.**

1. Same principles that are used in the second year.
2. Surplus branches and dead and broken limbs must be removed.
3. The leaders and long side limbs must be shortened-in to keep the top low, strong and spreading.
4. Side limbs with bearing twigs must not be pruned.
5. All cuts should be made just above a side limb or bud.
6. Pruning should be from top downward.
7. Cuts should be made right up to the trunk or supporting branches.
8. Wound one inch across or larger should be covered with paint or grafting wax.

Fig. 103 Shows a three-year-old Frances peach tree never pruned.

Fig. 104. Same as Fig. 103 well pruned.

9. Study shape of top, leaders, and how to prune it.
10. Study how the leaders are cut back.
11. Study how the top is thinned by heading-back and out.

d. **Pruning four-year-old trees.**

1. See second and third years.

Fig. 105, Shows a neglected four-year-old peach tree. (Paddock and Whipple.)

Fig. 106, Same as Fig 105 properly pruned. (Paddock and Whipple.)

2. Tell how Fig. 105 was pruned.
3. Study the shape, top, leaders, and how to prune trees that are four years old.

Fig. 107. Shows a five-year-old Elberta never pruned.

e. **Pruning five-year-old trees.**

1. See second and third years.
2. Note the long-legged, bare-branched, high-topped tree.
3. How should it be pruned by heading-out or heading-in.

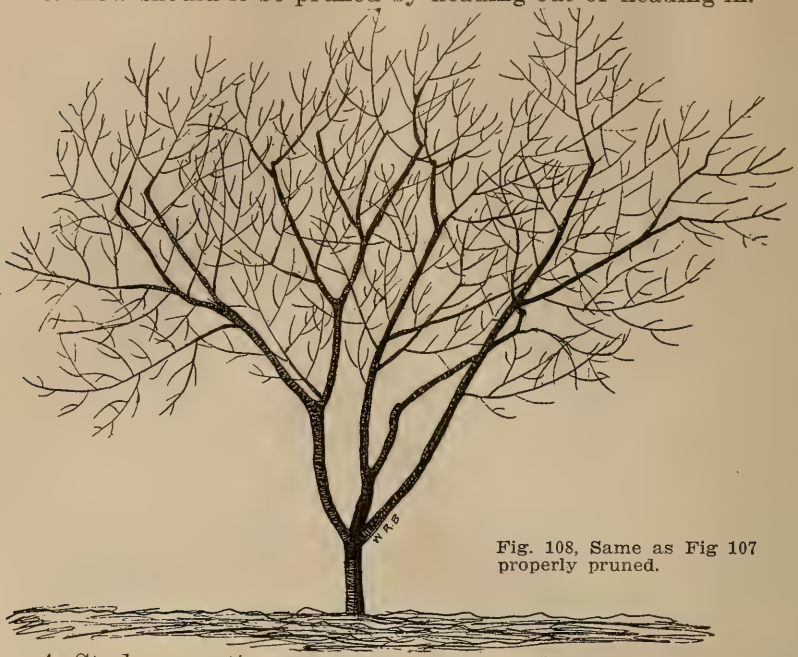


Fig. 108, Same as Fig 107 properly pruned.

4. Study how the tree was pruned and explain why certain branches were cut off.

7. **Low-headed tree.**

a. Fig. 109 shows a well-trained, low-headed tree.
(Paddock and Whipple.)

b. The top forms a right angle and the spread is double the height.

c. The productiveness is increased by forming a spreading top rather than a high top.

8. **Dehorning large limbs.**

a. Fig. 110 shows how to dehorn old trees.

b. The rejuvenating old peach trees is an important principle and should be carefully considered before it is undertaken.

c. The best time is when the crop has been killed by late frost.

d. It should be done as soon as possible after the loss.

e. Rejuvenating and dehorning are necessarily the same in their mode of operation.

f. All adventitious growth and suckers should be removed as soon as they begin to form.

Fig. 110, Shows dehorning large limbs. (Paddock and Whipple.)

g. The equilibrium of the tree has been so much upset by the heavy pruning that water sprouts and suckers may arise for several years.

9. **Bracing.**

a. The limbs of two scaffold branches that need to be braced are twisted together as tightly as possible.

b. Many trees are easily braced in above manner.

c. The limbs that are twisted together will produce fruit spurs.

d. Fig. 111 shows how to brace a top by using wire braces.

Fig. 111, Shows how to wire-brace a top.

5. Apricot.

1. **General principles.**
   a. The general plan of planting and pruning the apricot will resemble the peach but not quite as severe in pruning.
   b. Young apricot trees that are strong growers must be put through about the same course of pruning as the young peach.
   c. Pruning the apricot like the peach, will strengthen the frame branches and develop a broad, low-headed tree.
   d. Sometimes, simply heading-back the new strong growth will be sufficient to keep the fruiting wood growing thriftily.
2. **Forming the top.**
   a. Follow the plan of the peach.
3. **Study the location of fruit-buds.**
   a. Fruit buds are developed in the axils of the leaves on
      1. Shortened spur-like twigs.
      2. Stronger growing branches.
      3. Both of current season's growth.
   b. Fruit spurs develop no true terminal buds.
   c. Lateral bud may be a fruit bud or a branch bud.

6. Cherry.

1. **General principles.**
   a. The planting and pruning the cherry will resemble the apple but not quite as severe in pruning.
   b. The cherry tree is hardy and readily adapts itself to varied conditions.
   c. The cherry tree should have a rather dry sandy loam to light clay loam; rich in mineral plant food but poor in nitrogen, with a porous subsoil, well drained.
   d. The cherry requires little pruning after the first two or three years.
   e. Forming the top.
      1. Some prefer to have a low-spreading top composed of from three to five branches.

Fig. 112 shows the top of a sweet cherry.

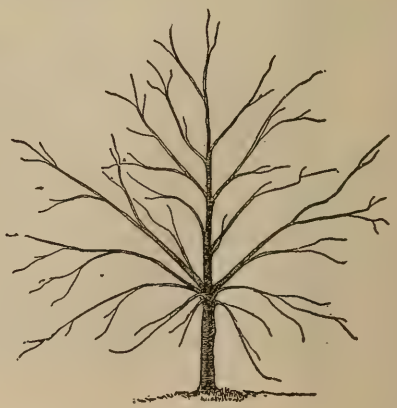


Fig. 113 shows the top of a sour cherry.

2. The fruiting area should be kept as near the ground as possible; to shade the trunk, to prevent sun-scald, and to encourage the growth of the fruiting wood throughout the entire top.
3. The sweet and semi-sweet varieties are upright growers and should be headed back to keep them within bounds.
4. The sour varieties are spreading growers and should be headed-in.
5. The growing of weak fruit-buds is a sign that the tree is not pruned enough; heavy pruning during the dormant season will often correct the fault.
6. Lack of bloom is generally due to excessive pruning or to much water.
7. Study the location of fruit buds.
   a. See Apricot.
   b. Fruit is borne on one-year-old wood, and also mostly on short growths, or spurs.
   c. Spurs carry.
      1. Terminal buds which are generally a branch bud.
      2. Axillary buds which are generally a fruit bud.
   d. The fruit buds are found as axillary buds near the base of the strong-growing new wood.

7. Plum.

1. **General principles.**
   a. The varieties; as, Burbank, Abundance, Salsuma, Red June, and others of the Japanese groups resemble the apricot in system of pruning.
   b. The Domestica plums represented by the prunes are pruned very little, except the varieties that over bear require a certain amount of thinning out.
   c. The habit of the plum to bear early and abundantly under favorable conditions limits its annual growth so that little pruning is necessary other than to remove dead or interfering limbs or to head back an occasional strong shoot which may appear from time to time in the center of the crown.
   d. The plum, as well as the cherry, has the annoying habit of occasionally producing strong shoots from adventitious buds along the trunk of the tree or from near the surface of the ground.
   e. A close watch should be kept for such interlopers in order that they may be promptly removed.
   f. In the early period of the growth, the annual growth will need more or less severe cutting back, depending upon the soil and climatic conditions, in order to maintain them within bounds.
   g. On general principles, this heading should be done just before the growth starts in the spring.
2. **Forming the top.**
   a. Some varieties require heading-out to spread the tops.
   b. Other varieties require heading-in to compact the tops.
   c. They should be low-headed to protect the trunk from sun-scald.
   d. There should be annual heading-back and thinning out to force strong new growth.

3. **Study the location of fruit-buds.**
   a. No terminal buds, with few exceptions.
   b. Last axillary bud is generally a branch bud, except on weak spurs.
   c. Branch or spur is the growth of last year's bud.
   d. Fruit buds are developed in the axils of the leaves on both spurs and ranker growing new wood.

References.

1. See references under planting an orchard.
2. Send to the Washington Nursery Co., Toppenish, Wash., for a complete descriptive book of the different varieties of fruit; of ornamentals, shrubs, vines, shade trees, flowering plants and bulbs.

THINNING.

1. **Object:**
   a. To maintain the vigor of the trees.
   b. To secure annual crops instead of alternate.
   c. To produce fruit of maximum size, color and quality.
   d. To increase commercial value.
2. **Methods:**
   a. **Pruning.**
      1. Study the location and habits of the fruit buds of the different classes of fruit trees.
      2. Remove the superfluous branches.
      3. Winter pruning tends to produce wood.
      4. Summer pruning tends to produce fruit by checking the growth of the branches.
      5. Successful fruit growers understand the importance of pruning to gauge the quantity of fruit allowed to be borne by a tree to the capacity of the tree.
      6. The ability of the tree in this respect is measured by the growth, the variety, the soil and climatic conditions, to which it is subjected.
      7. Pruning the co-terminal fruit-bearing plants; those which bear their fruit upon the growth which grows the same year the fruit does and which springs from last year's growth.
      8. If fruit spurs or twigs burst into growth, it is usually best to head them back each year to their original length, rather than cut them off entirely.
      9. Remember, that fruit spurs bear fruit and not leaves and when they are cut off, the tree is not only thinned but the fruit bearing region can never be grown on again.
      10. It should be here noted that the tendency to grow rapidly is the most pronounced in young trees, hence the pruning should be more severe than in old trees of the same variety.
      11. The disadvantage of pruning to thin the fruit is that you do not know how many buds or young fruit may subsequently be destroyed by disease or cold.
      12. Properly pruned trees generally need little thinning of fruit.
      13. Thin out the trees that are too close in the tree rows.

b. **Hand-thinning of apples.**

1. Picking off redundant fruits.
2. Requirements vary with different individual trees and with the same tree at different season.
3. Important conditions.
   a. The different varieties.
   b. Age and condition of trees.
   c. Amount of fruit which has set.
   d. Distribution of fruit on trees.
4. **The ways of thinning.**
   a. To remove all wormy and inferior specimens.
   b. To remove all terminal fruit on long, slender branches.
   c. To remove all limb-bruised and frost-marked fruit.
   d. To remove all but one fruit from each cluster.

Fig. 114, Shows a Winesap branch three feet long before and after thinning. (Colorado Exp. Station.)

5. **Distance for apples.** Fig. 114.
   a. Some varieties are thinned from 9 to 10 inches apart on old trees.
   b. Other varieties are thinned from 6 to 8 inches apart on young trees.
   c. Proper distance prevents limb-bruised fruit caused by wind.
   d. The size of the fruit determines in a measure the distance that the fruit should be left apart on the limb.
6. **Principle of alternation.**
   a. All the fruit should be removed from some of the spurs.
   b. This gives the spurs time to form strong fruit buds for the succeeding year.
   c. The older the tree, the more fixed is the habit of alternation of bearing fruit, hence thinning should be commenced as early in its growth as possible.
7. **Time to thin.**
   a. Natural thinning takes place in June—"June Drop."
   b. Generally after June Drop.
   c. June and early July is the proper season to thin apples and pears.
8. Commence at the top of the tree and work down.
9. Fruit on lower limbs next to the trunk should be thinned a little farther apart on account of the shade.
10. In thinning always "look up and not down."
11. Be sure that every branch is so thinned that it will support a load of natural fruit.
12. Fruit spurs with terminal fruit buds, as those of the apple and pear, generally bear only alternate years, and if the spurs are all full of fruit one year, the next may be an "off year."
13. Not only do the spurs fail to bear annually, but if the tree is

overloaded, spurs that produce bloom, even though they fail to set fruit, may not be sufficiently nourished to produce fruit buds for the following season.

14. If the tree bears only a moderate crop of fruit, spurs that produce bloom but no fruit, often develop fruit buds the same season.
15. Where the tree is bearing a light load, spurs may mature fruit and develop fruit buds the same season.
    a. Much depends upon the general thrift of the trees, and, as in pruning, the grower will have to learn much by experience.
16. Some thin to leave the fruits so far apart, but a rule fixing a certain space between apples will not hold good in all cases.
17. If we were always sure the tree had been properly pruned, we might be able to give a satisfactory rule to be followed, leaving the fruits so many inches apart.
18. Suppose you decide that the trees should produce ten boxes of fancy fruit each.
    a. Fairly uniform grade of apples ranging from two and one-half to three inches in diameter will pack from 96 to 125 to the box and by thinning two or three trees and leaving from 960 to 1250 apples, actually counting them or estimating them as closely as possible, one learns what a tree properly thinned should look like.
    b. With these trees as a model it is surprising how close one can come to leaving just the right number.
    c. I think it is possible, by careful work, to come within a box of the ideal.
    d. By knowing how much the tree should produce is where the experience counts.

c. **Hand-thinning of pears.**

1. Methods of thinning pears differ little from methods of thinning apples.
2. As a rule, the pear tree will produce about as many boxes of pears as will the apple tree of the same age produce boxes of apples.
3. The fruit is generally picked on the installment plan, and it is possible to mature a large crop of fancy fruit; and fruit that is small may be left until it reaches the decided size.
4. Pears running from 135 to 150 to the box are considered ideal size, and pears for such a pack must measure from two and one-fourth to two and three-fourths inches in diameter.
5. Pears larger than three inches are really not as desirable for the fancy fruit trade as those of smaller size.

d. **Hand-thinning of peaches.**

1. In growing peaches much of the thinning is done with the pruning shears during the pruning season, but additional hand-thinning is absolutely necessary.
2. The thinning should be done before the foliage gets too heavy and before the pits begin to harden.

3. The pruning shears may be used as a help in thinning, and fruiting wood not necessarily needed may be removed entirely.

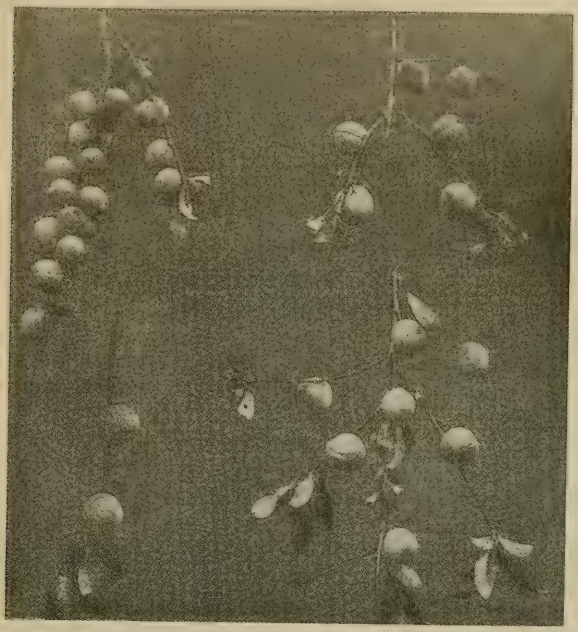


Fig. 115, Shows how to thin an Alexander peach tree.

4. Fig. 115 shows the results of thinning.
   a. Upper left—neither pruned nor thinned.
   b. Upper right—moderately pruned, thinned to 4 inches.
   c. Lower right—moderately pruned, thinned to 6-8 inches.
   d. Lower left—heavily pruned, thinned to 6-8 inches.
5. A good grade of peaches should run less than 90 to the box, and we may say it seldom pays to ship smaller fruit.
6. A size that will pack less than 80 to the box is desirable.

3. The market demands generally what you do not have.
   a. When there is a large crop of fruit, there is an over-supply of small fruit—thin accordingly.
   b. When there is a small crop of fruit, there is usually an over-supply of large fruit—thin accordingly.

4. **Questions.**
   a. Does heavy seed production cause trees to bear crops one year and lessen the amount of fruit the following year?
   b. Do fruit spurs produce fruit and fruit buds the same year?
   c. How are fruit buds produced?
   d. What effect on fruit buds if the fruit spurs produce a full crop of fruit?
   e. How many boxes of apples should a tree produce? Pears? Peaches?
   f. What effect has sunshine on fruit?

g. What causes one side of a tree to bear fruit lightly and the other side heavily?
h. Does the fruit tree furnish the same amount of plant food to the fruit that is left after thinning as before thinning?

5. **References.**
a. The Pruning Book by Bailey.
b. The Principles of Fruit Growing by Bailey.
c. Fruit Growing by Paddock and Whipple.
d. Colorado Bulletin No. 139.
e. Colorado Bulletin No. 170.
f. New York Bulletin No. 77.
g. Montana Bulletin No. 77.
h. Pennsylvania Bulletin No. 106.

1. GRAPE CULTURE.

a. Propagation.

1. **Cuttings.**
a. See Propagation.
b. Make cuttings of the last season's growth as soon as the vines are matured.
c. Let the cuttings be from 8 to 20 inches long; the hotter and drier the climate, the longer the cuttings.
d. Make the cuttings from young, well-matured, medium-sized and short-jointed wood.
e. Cut just below the lower bud, making the cut slanting, and about one inch above the upper bud to keep the bud from drying out.
f. Tie in small bundles (butts one way) and heel in or set in trenches (butt ends up) and cover with three to six inches of dirt.
g. Inverting the bundles causes the tops to remain dormant while the butts callous.
h. When the cuttings are planted in the spring, the rootlets readily grow before the tops.
i. If this is not done the tops start to grow before their roots form to support them.
j. Plant in the spring in deeply plowed and mellow ground, in rows three to four feet apart and the cuttings three to four inches apart in the rows.
k. Place so deep that but one eye or bud remains above the ground.
l. Keep the soil clear of weeds, cultivating very often.
m. Do not irrigate often, but cultivate constantly.

2. **Laying.**
a. See Propagation.
b. This method is usually followed in the Rotundifolia vines and a few others which do not start readily from cuttings.
c. Choose a cane of last season's growth which has started near the

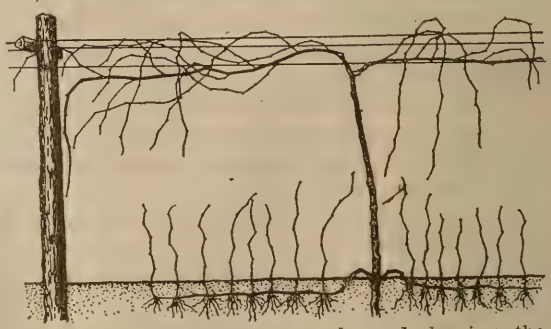


Fig. 116. A vine with two canes layered, showing the method of propagation by layers.

base of the vine, and fasten down in a trench about three inches deep.

d. Each bud on the cane will usually produce a shoot growing upward.

e. After the shoots are well started and rooted at the base, the trench should be filled with soil.

f. A slight incision opposite each shoot will assist the formation of roots.

g. During the fall or winter the plants may be taken up and divided.

3. **Grafting.**

a. See propagation.

b. This is done by cleft grafting or veneer grafting, if on large stocks as top-working; tongue grafting, if upon small roots.

c. Treat as in regular nursery practice.

b. Planting a vineyard.

1. **Time of planting.**

a. The spring is the best time to set out grape plants.

2. **Selection of plants.**

a. Two years old vines are the most popular for planting.

b. Yearlings of the strong growing varieties, as the Concord and Niagara are frequently planted.

c. The vines should be free from diseases.

3. **Varieties.**

a. The Concord and its family, Brighton, Niagara are strong growers.

b. The Catawba is a very strong and upright grower.

c. The Black July, Sweet-water and Delaware are weak growers.

d. By careful computation it has been found that the greatest yield of grapes is from the fourth to the sixth buds inclusive of the Concord; from the seventh to the ninth of the Niagara, Delaware and Brighton.

e. With this idea in mind they should be pruned and no more than twelve buds to the cane should be left.

4. **Distance to plant.**

a. Strong growing ones are usually planted eight to ten feet apart in the rows and the rows from eight to nine feet apart.

b. Delawares and other small growing vines are planted closer.

5. **Before planting.**

a. The roots should be cut back to 3 to 4 inches.

b. One cane should be left and it should be cut back to two or three buds and let grow on the ground the first year.

c. All suckers and scion roots on grafts should be removed.

6. **Set out the plants.**

a. The top bud should only project above the ground.

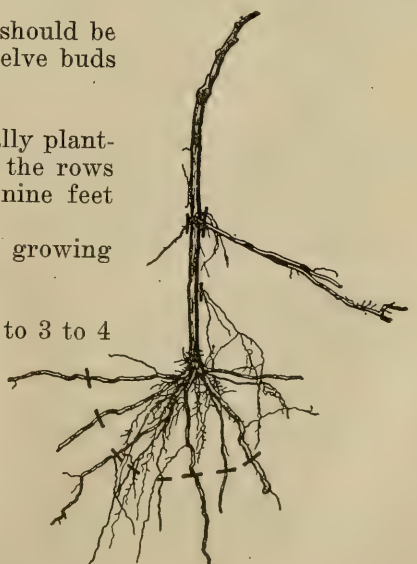


Fig. 117, showing where to prune the roots ready for planting.

b. If cuttings are planted, set two in each place in order to get a stand, it is easy to pull one out if both grow.
c. The hole should be broad and rounded up in the center of the bottom.
d. Fine pulverized soil should be put around the plant.

c. **Grape Terminology.**

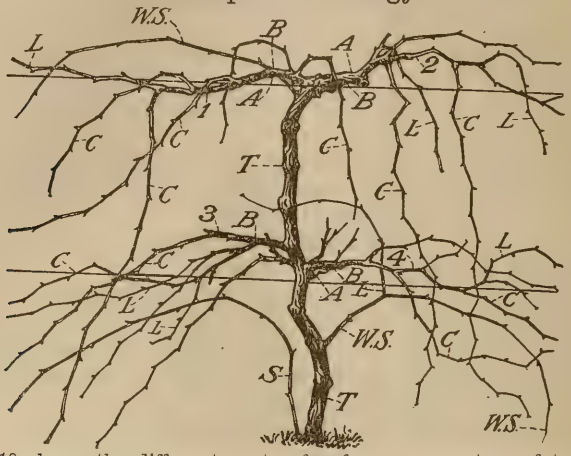


Fig. 118 shows the different parts of a four-cane system of training.

1. **Nomenclature,** Fig. 118.
   a. A's are the arms and are two or more years old.
   b. B's are the branches of matured wood and may be several years old.
   c. C's are canes, called shoots when green and canes when matured.
   d. L's are the laterals, the secondary shoots of a cane.
   e. S's are suckers, the shoots starting below the ground, from the main body.
   f. T is the trunk, stem, or main body of the vine.
   g. W.S.'s are water sprouts which start from wood older than one year.
   h. The two-year-old arms are 1, 2, 3 and 4.
   i. The basal eye or bud is near the base of the cane and it is not counted in reckoning the number of eyes on a fruit spur.
   j. When more than four eyes of a cane are left in pruning, it is called a fruiting cane.

d. **Pruning.**

1. **Principles.**
   a. The sap flows with greatest force as it nears the extremity of the canes.
   b. The more upright the branch is, the more sap flows into it; the more abundant and active the sap, the greater the wood growth and larger and later the fruit.
   c. If the sap is checked, the plant bears earlier and produces more and richer fruit.
   d. The fruit is borne upon new shoots which spring from last year's growth.
   e. The time for pruning is in early spring or late winter, but the

vines should not be cut when frozen or when the sap flows rapidly.

f. The vine should be cut off an inch or so beyond the last bud so that the last bud will not dry out.

2. **Methods.**
   a. Remove all the diseased parts and suckers.
   b. Shorten the extended shoots, side shoots, and laterals.
   c. Put upright the parts whose rapid growth is desired.
3. **Pruning the stem.**
   a. It may be done at any time during the winter when the vine is dormant.
   b. The extent depends on the growth made.
   c. If the growth is small, all the canes except the strongest should be removed and the strongest cut back to two eyes.
   d. If a strong growth has been made and there is one straight well ripened cane, all other growth should be removed and the strong cane cut back to the height intended to form the head.
   e. In the fall or winter all the canes but one, are cut off and this one is cut back to two or three buds.
   f. From this it will be seen that at the beginning of the second season's growth the vine is no larger than at the beginning of the first season after planting.
   g. It must be noted that the roots have become well established for the second season's growth.

Fig. 119 shows a pruned vine at the end of the first year.

4. **Winter pruning.**
   a. All three-year-old vines should have erect, straight stems with two or more canes growing from the trunk, on which the head or crown is to be formed and from which the growth of the vines is to be renewed from year to year.
   b. Prune and shape or adjust the main body or permanent parts of the vine to the desired system.
   c. Then the fruit bearing part of the plant should be so pruned that the vine will be renewed from year to year; never allow the vine to overbear but make it bear to its full capacity.
   d. Below the basal buds are one or more dormant buds, which produce sterile canes when too few eyes are left in pruning, thus forcing them to grow.
   e. If one of them grows the same season it is formed, it makes a lateral from which a secondary lateral may also grow.
   f. The first and secondary laterals bear the second and third crops of grapes.
5. **Summer pruning.**
   a. When the vine is cut back to two buds, only one should be allowed to grow.
   b. All other young shoots should be removed.
   c. When the shoots have grown to a foot above where it is intended to head, they should be topped slightly above where the head is to be formed, causing laterals to grow where they are desired.

Fig. 120. Vines headed back for different systems of training; A, the spur and fan system; B, the four-arm renewal system; C, the two-arm Kniffin, Munson, umbrella and overhead system.

d. Summer pruning is practical on the young growth to regulate the quantity of fruit and the shape of the plant.

e. The only summer pruning that should be done is to rub off the superfluous shoots growing from the base of the trunk or from the trunk, buds as S and W.S., Fig. 118, and the secondary branches which frequently start from the base of the season's growth.

e. **Different systems.**

1. **The high-renewal system.** Fig. 122.

a. The high-renewal system of training requires a trellis consisting of three or more wires or other suitable supports carried by posts or stakes placed at convenient distances apart in the row of grapevines, the vines themselves being planted 8 to 10 feet apart in the row.

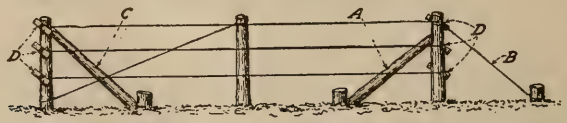


Fig. 121, Diagram of an ordinary trellis, showing the braces (A, B, C) and devices (D) used for tightening the wires.

b. **Trellis.**

1. The first or lowest wire of size No. 12 upon the trellis is usually 18 to 20 inches from the ground.
2. The next wire of size No. 11 to 12 is about 20 inches higher, and the third about 3 feet still higher.
3. The main trunk of the vine is carried to the height of the lowest wire or support.

c. **Principles.**

1. If the high renewal or upright system is followed to train the vine by, all of the season's growth is cut off each year, except the head of the vine.
2. This leaves a cane or spur on each side, so that the canes can be tied to the wire.

3. The length of the cane and the number of eyes left on the vines will vary with the variety and size of the vine, but roughly speaking, 20 to 30 eyes for weak growing ones and 40 to 50 for strong growing vines.
4. A cane carrying about eight buds is trained in either direction along the lowest wire.
5. From each of these buds shoots develop which bear the crop of the season; but as these shoots are seldom able to care for themselves they must be tied to the upper supports of the trellis.
6. It will be noted from this that the summer tying of plants trained on this system is very much greater than with plants trained on the Kniffen system.
7. From the T head which, as has been stated, is carried to the height of the lowest wire, canes are carried in both directions along the lowest and are firmly tied to it.
8. Near the base of each of these canes, but upon the older wood of the T head, short spurs carrying two or three buds are maintained, A and B, Fig. 123, from which shoots develop which in turn are usually employed to furnish the fruiting canes of the succeeding year; that is, the spurs are the means of renewing the fruiting wood of the vine grown on the high-renewal system.

d. **Pruning.** Fig. 122.

1. **The end of the second year.** (A).
   a. At the close of the second season after planting, you should have a vine like the illustration; with two good canes extending in the opposite directions, and tied to the wire.
   b. The pruning this year should be to cut off the ends of the canes back to firm, strong wood, leav-

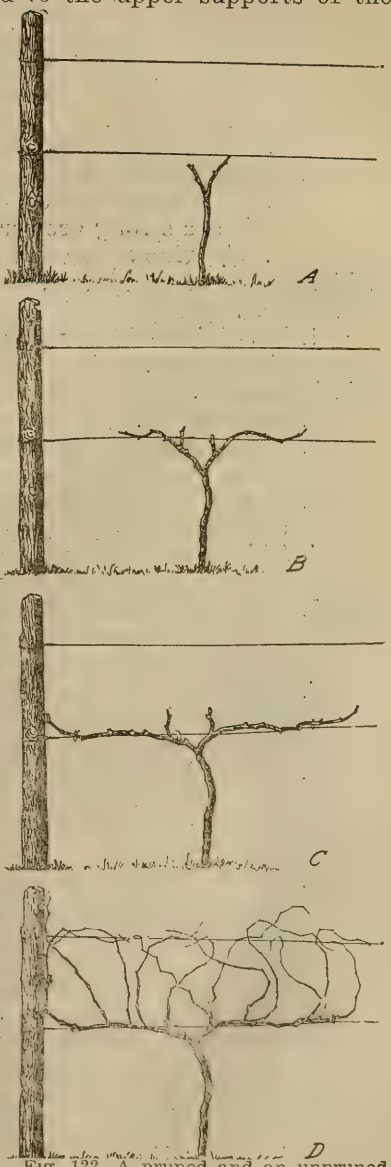


Fig. 122. A pruned and an unpruned vine at different ages.

ing from five to eight buds.

c. Observe the renewal stubs, one on each side of the crotch on B.

d. If the second season's growth is too weak to support the arms which are now to be formed upon it, cut it back at the end of the second season, as at the end of the first season.

2. **The end of the third year.** (B)

a. The third year's shoots will grow upright from these five to eight buds and should be tied to the upper wire, or they may be allowed to droop from the first wire to the ground.

b. Some of the upright shoots will bear a crop the third year, but unless the vines are strong, the flower clusters should be removed.

c. The vine is pruned at the end of the third year like (B).

3. **The end of the fourth year** (C and D).

a. At the end of the fourth season the vines look like (D) if it is a strong grower.

b. The vine at the end of the fourth year is pruned like (C).

2. **Kniffen four-cane system.**

a. **Trellis.**

1. It consists of two wires; first 30, and second, 56 inches above the ground.

b. **Principles.**

1. See Fig. 118.
2. Two canes and two spurs of last year's growth are left at the lower wire; two canes and two spurs at the top vine.
3. It will be noted that the long trunk employed in the Kniffen system carries the fruiting branches far above the ground.
4. This permits the annual growth to fall from the supporting wires in a natural way without the necessity of tying.
5. Slight advantage which the Kniffen system has over high-renewal system is that the fruits are farther from the ground and less liable to injury from mildew and rot.
6. They are also somewhat easier to spray, although there is comparatively little difference in this regard between the Kniffen and the high-renewal system.
7. The Kniffen system consists in the carrying of either one or two main trunks to the height of 3 to 5 feet above the ground; sometimes they are carried to the height of 6 feet or more.
8. If two trunks are employed, one is carried 6 feet or more above the ground and the other about 18 to 20 inches lower.
9. It is not desirable to attempt to make two stories on a single trunk as the laws of growth induce development at the extremity of the cane and therefore the set of branches which are the lowest upon a common trunk makes little or no development, growth being confined almost entirely to the uppermost set of branches.
10. When two trunks are employed, the case is different and each set of branches becomes, as it were, terminal branches and a much more satisfactory growth results.

c. **Pruning.**

1. The method of renewal employed in the Kniffen system is practically the same as that in the high-renewal system; that is, the canes which are to bear the fruit during the next season are selected from wood which developed the previous year.
2. These canes are cut back to six or eight buds and are tied to the central wire of the overhead trellis.
3. At the close of the season the bearing cane is removed and a new shoot, which developed from near the head of the trunk, is used to replace it during the succeeding year.
4. The same treatment is employed for the other side of the head; that is, the T head at the top of the trunk on the Kniffen trained vine serves the same purpose as the T head at the top of the trunk of the high-renewal vine.
5. The vine trained according to the four cane Kniffen system at the end of the fourth year is shown in figure 128.

3. **Kniffen two cane system, or Umbrella system.**

a. **Principles.**

1. The trunk of the vine extending directly to the top wire where the growth is annually cut back to two canes and two spurs, one on each side, which are fastened to the top wire.
2. The absence of the two lower canes insures a good upright trunk and the renewal of the fruit bearing wood to one head makes the vine more easily pruned, leaves less old wood, and results in a cleaner and better ventilated vines.

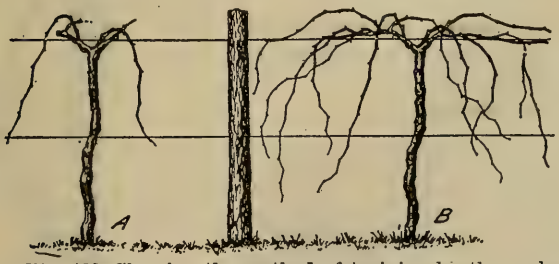


Fig. 123, Showing the method of training by the umbrella system. At the end of the fourth year (A) pruned vine (B) unpruned vine.

b. **Pruning.** Fig. 123.

1. See pruning of the four cane system.

4. **Short pruning system.**

a. This system is also called the spur or stool system, and is extensively used in California, especially with the stockier growing varieties.

b. The body of the vine is first allowed to grow to the desired height and shoots are permitted to grow only from the two uppermost buds.

c. Two canes thus resulting are cut back in the winter to spurs of two eyes each.

d. Next year, these spurs are allowed to pro-

Fig. 124, A pruned vine in its fifth year, showing the method of training by the spur, stool or short system.

duce growth and the canes thus resulting, are again cut back to spurs which are allowed to remain if the vine is strong enough. Fig. 120A.

e. At the end of the fourth or fifth year the vine should consist of a trunk from which springs four or five arms on each of which a cane has been cut back to a spur as illustrated by Fig. 124.

f. When the vine is again pruned, all or nearly all of the outer canes that have grown then from the spurs are entirely removed.

g. The spurs of the last season are cut off just outside of the inner canes, which are cut back to spurs, after this, the pruning each winter is to promote a regular system of spur renewal.

h. The older the vines, the stronger they get and hence more spurs may be left on to increase the fruiting capacity of the plant.

i. In time the arms upon which the spurs are borne will have to be renewed.

j. Essay to keep the head of the vine vase-shaped.

k. Vines like the Niagara, Delaware and the Brighton, which have poor growth from the first may be improved by increasing the length of the spurs and number of eyes, leaving four or five eyes.

f. **Comparison of the different systems.**

1. **The four cane Kniffen system.**
   a. See Figure 118.
   b. Its advantages over the single stemmed Kniffen is that the laws of growth encourage the greater development of the upper set of branches at the expense of the lower.
   c. The advantage of these two systems is that the canes fall naturally upon the wires and are easily tied.
2. **The two-cane Kniffen system.**
   a. See Figure 123.
   b. It is an improvement over the four caned Kniffen in that the absence of the two lower canes insures a good upright trunk.
   c. The renewal of the fruit-bearing wood to one head, makes the vine more easily pruned, and leaves less wood and resulting in a cleaner and better ventilated vine.
3. **The High-renewal system.**
   a. See Figure 122.
   b. The only difference between this and the above two is that the new growth of the latter must be tied up to the higher wire, rather than be allowed to fall to the ground.
   c. This necessitates a great deal more work in the summer and also more wire.
4. **The Horizontal-arm spur system.**
   a. See Fig. 126.
   b. This is the same as the above ones except that the arms are left

Fig. 125, A pruned vine in its fifth year, showing the method of training by the cane system.

on and the new growths are made from the canes which are left upon the arms and are renewed thereon every year.

c. This method gives more surface upon which the new growth is made.

d. New spurs are grown from the horizontal arms to replace the old one and for the new shoots to start out from.

e. Heavy wood-growing varieties may be successfully pruned this way.

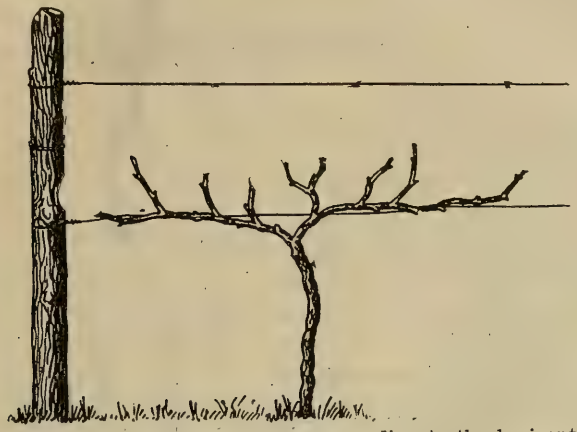


Fig. 126, A vine in its fourth year according to the horizontal arm spur renewal system.

5. **Fan System.**

a. See Figure 127.

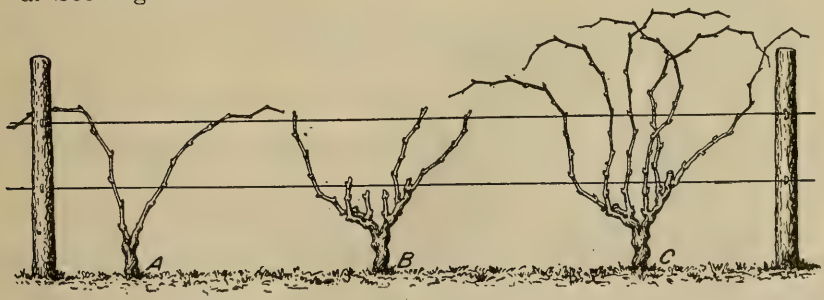


Fig. 127, A vine at different ages, showing the method of training by the fan system; A, an unpruned vine in its third year; B, a pruned vine in its fourth year; C, an unpruned vine in its fourth year.

b. In this method most of the old wood is disposed of each year.

c. The vines can be laid down and covered each year if the climate is severe; and the young growing shoots can be laid across the wires and the tendrils catch onto the wire doing away with the necessity of tying.

d. The renewals are seen in B, and the explanation at the base of the illustration is sufficient to enable the operation to be understood.

6. **Short system.**

a. See Figures 124 and 120A.

b. The advantages of this system are that it is the simplest, easiest and cheapest method in use.

g. Pruning old vines.

1. The vines in figure 123 show how they were pruned for the first four years according to the two-cane system which will also represent how the top is formed in the other system.
2. The vines in figure 120 show how the vines of the different systems are pruned at the end of the third year.
3. Let the vine in figure 118 represent the growth at the end of the fifth year.
   a. The two-year-old arms (1, 2, 3 and 4) which grew during the previous summer, were the only ones allowed to remain of all the canes when the vine was pruned in the winter.
   b. When the canes (1, 2, 3, 4) were first left, they were tied to the wire.
   c. The canes grew from the above arms and bore fruit the next summer.

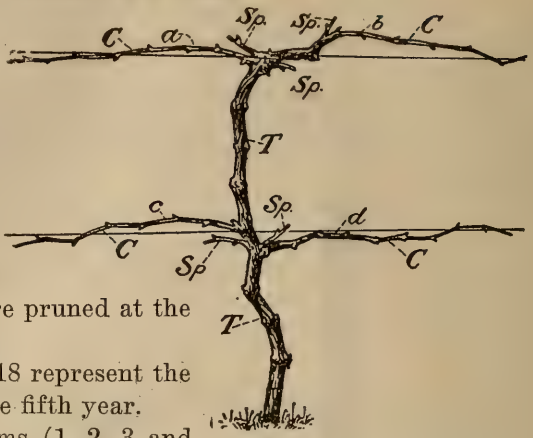


Fig. 128, A vine pruned according to the four-cane Kniffen system; C, canes, called shoots when green and canes when mature; Sp., spurs, canes cut back to one to four eyes; T, trunk, the stem or main body of the vine; a, b, c, d, arms succeeding those shown at their 2-year-old stage in figure 119 at 1, 2, 3, 4.

4. Study the parts of the figure 128.
5. The vine in figure 118 is pruned the following winter and it looks like the vine in figure 128.
   a. The canes (a, b, c, d) were only left and tied to the wire as the arms (1, 2, 3, 4) of figure 118.
   b. The canes (a, b, c, d) are only one year old but become arms when canes grew upon them.
   c. The C canes in figure 128 in the spring should never be more than one year old.
   d. This necessitates a constant renewal of wood for the bearing surface.
6. **The renewal of spurs.**
   a. This is affected by keeping a new growth Sp in Fig. 128 growing each year, out of which shoots grow to become canes upon which the next year's crop is to grow.
   b. These canes grow from Sp shoots while the present crop is being borne upon C. canes in Fig. 128.
   c. The spur, Sp. in Fig. 128 should be cut to from one to four buds from which the new canes start.
   d. Remember the basal buds do not grow strong shoots and for that reason should not be left on.
7. The entire vine, Fig. 118 is pruned in ten cuts.

h. Renewal.

1. It must be remembered that we must have some method of renewing the tops or bearing wood of the vine.

2. In order to do this intelligently, we must remember that the fruit is borne in a few clusters near the base of the growing shoot of the present season and that these spring from wood of last year's growth.
3. Each bud on the old cane produces a new shoot which may bear fruit as well as leaves and then the shoots ripen into canes.
4. These canes have buds every foot or less from which a new fruit bearing shoot may start in the next spring.
5. The cane cannot bear a shoot for every bud, therefore it is necessary to cut off the cane leaving only as many buds as experience teaches that the variety can stand.
6. This is from five to ten buds, never more than ten.
7. Each shoot from these should bear from two to four clusters.
8. From two to five canes not bearing over five to ten buds, each should be left for each spring growth.
9. It will be seen from this that the constantly ageing of the main branches, B. Fig 118 extending into A, Fig. 118, will have a tendency to keep carrying the fruit bearing wood away from the main body or trunk of the vine.
10. It is for this reason that the little growths are started as in B and C, Fig. 122 and A and B in Fig. 123.
11. As the wider extending two branches age and carry the fruit bearing wood farther and farther away from the trunk, these two renewal stubs may be bent down to the wire and fastened to the wire and then the older arms cut off in due time.

i. **References.**

1. See References under Thinning.
2. U. S. Dept. Bulletin No. 471.

STRAWBERRIES.

1. **Propagation.**
   a. By seeds to secure new forms.
   b. By Stolons.
2. **Time to plant.**
   a. Spring planting is preferable because the soil is moist, warm and in better condition for the plants.
   b. Fall planting is practiced but the plant has not time to produce a large crown system before winter.
3. **Selection of plants.**
   a. Plants that have developed strong crowns and healthy root system are capable of producing large crops.
   b. Plants that are formed by stolons should be used.
   c. Plants from the old bed should be avoided as continued fruiting saps the vitality and prevents the development of strong runners.
   d. **Pollination.**
      1. **Bi-sexual** or perfect plants have power of producing both stamens and pistils.
         a. Bi-sexual varieties.

Aroma	Oregon Iron Clad
Brandywine	Parker Earle
Clark's Seedling	Parson's Beauty
Gandy	Rough Rider

Marshall	Senator Dunlap
Midnight	Wm. Belt
Miller	

2. **Pistillate** or imperfect plants produce pistils only.
   a. Pistillate varieties should not be planted alone.

Buback	President
Haverland	Sample
Mark Hanna	

3. **Fruiting seasons.**
   a. Early to medium varieties.

Aroma	Parker Earle
Brandywine	Parson's Beauty
Clark's Seedling	Rough Rider
Midnight	Senator Dunlap
Miller	Wm. Belt

   b. Late varieties.

Buback	Marshall
Gandy	Oregon Iron Clad
Haverland	President
Mark Hanna	Sample

4. **Distance to plant.**
   a. **Hill system.**
      1. Plants are set singly either 3 by 3 feet apart or with rows 4 feet apart and the plants 2 feet apart in the rows depending on soil.
      2. The hill system affords more intensive cultivation.
   b. **Matted system.**
      1. Plants are set in single rows 4 feet apart with the plants 12 inches apart in the row, or the rows from 3 to 3½ feet apart and plants from 20 to 30 inches apart in the row.
      2. After the second crop has been harvested the runners can take possession of the cultivated middle; and when the plants are thoroughly established, the old rows can be broken up, thus cheaply renewing the patch.
   c. **Single-Hedge Row.**
      1. The plants are set in rows from 2 to 3 feet apart and the plants from 20 to 30 inches apart in the row.
      2. The mother plant is allowed to set two runners which are turned into the row.
      3. All other runners are clipped off.
   d. **Double-Hedge Row.**
      1. The plants are set in rows about 3 feet apart, and the plants about 30 inches apart.
      2. The mother plant is allowed to set four runners, one from each side of the plant.
      3. Superfluous runners are clipped off.
      4. This eliminates crowding and permits plenty of sunlight and air.
5. **Before planting.**
   a. Plants should be heeled-in by digging a trench deep enough to cover the roots and laying in the plants close together in a single

row with roots spread out, and the soil should be pressed firmly around the roots leaving the crowns and leaves exposed.

b. When transplanting, the roots should not be exposed to wind as drying out of the roots is very detrimental to the life of the plant.

c. Dip the roots in water and place the plants in small bundles then wrap with a damp cloth.

d. Prune off all diseased and dead leaves and all large ones except one or two of the thriftiest.

e. Prune off about one-third of the roots.

6. **Setting out the plants.**

a. A shovel-toothed cultivator can be used for making the rows.

b. The hole may be opened with spade or trowel and the plant placed in at the proper depth.

c. The roots should be spread apart like a fan.

d. The crown should be just at the surface of the soil.

e. The soil should be pressed firmly against the roots of the plants.

7. **Pruning.**

a. Runners exhaust and check the plants more than weeds.

b. If strong plants and large excellent fruit, are desired, the runners should be kept off by pruning once a week through the summer.

c. Begin to prune as soon as the plants begin to form runners.

d. Sometimes a strawberry pruner is used, which is made out of a heavy sheet-iron about 30 inches long and 6 inches wide, the ends riveted to form a cylinder about 9 inches in diameter; the edge should be kept very sharp.

8. **Irrigation.**

a. The water is best applied in small rills close to the row.

b. Use a small amount of water over a long period on soils that have a tendency to puddle instead of a large amount for less time.

c. Coarse open soils should receive copious waterings of shorter duration than fine soils.

d. Irrigate for plants when the ground begins to get dry, and two or three times a week when the berries begin to ripen in order to make big berries.

9. **Cultivations.**

a. Intensive cultivation is essential to mature a large crop of berries.

b. General rules.

1. Strawberry plants are shallow rooted and cultivation should be shallow so as not to disturb the fibrous roots.
2. Dust mulch should be obtained to prevent evaporation.
3. Keep out the grass and weeds as they rob the strawberry plants of nourishment.

c. Thorough clean cultivation is the secret of success in strawberry culture.

10. **Mulching.**

a. The material used is whole or cut straw, straw manure or marsh hay.

b. It is to protect the plants from cold, prevents freezing and thawing and thus lifting of the plants.
c. It retards the growth in cold regions by shading the crowns and maintaining a low soil temperature longer than in soil not mulched.
d. It acts as a conserve of moisture, discourages weed growth of smothering the young seedlings.
e. It protects the fruit from contact with the soil.

11. **References.**
a. U. S. Dept. Bulletin No. 198.
b. Idaho Bulletin No. 70.
c. Delaware Bulletin No. 28.

2. Blackberries and Raspberries.

1. **Object of pruning.**
a. Removing superfluous shoots from the base of the plant so that no more than five or six canes remain.
b. Heading back the shoots when they reach the required height, thus causing them to throw out laterals and be more stocky.
c. Heading back these laterals next spring before the growth starts.
d. Cutting out the canes after they have borne rather than waiting to do this the next spring.

2. **The first step.**
a. The usual plan is to allow the young shoots which annually spring up from the root of the plant to grow to the height of 2 feet or a little more.
b. When the shoots have attained this height the first step in the pruning begins by breaking off 3 or 4 inches of the topmost portion of the shoot, leaving it 20 or 22 inches in height.
c. The rapidly growing succulent shoots snap off easily between the thumb and finger, and as a rule, no shears or other pruning device will be found necessary to accomplish this heading-in.
d. As a result of the check sustained by breaking off the terminal bud, the stalk thickens, the leaves grow larger, the axillary buds near the end of the stalk increase in size, and soon lateral shoots develop from them.
e. As a rule, five or six of the topmost buds push out and, instead of having one sturdy stalk several feet in length which would carry one-half dozen fruit clusters near its tip the succeeding season, pruning has restricted its height to 20 or 22 inches and has induced the formation of five or six lateral shoots, each of which may grow to be as much as 18 inches or more in length before the close of the season and, instead of a single cane for fruit production, there are five or six, each of which will carry as many fruit clusters as would have been produced by the original shoot, had it been left to itself.

3. **Second step.**
a. The second step in pruning consists in cutting out all the wood which is older than the present season's growth.
b. This pruning should be done immediately after the season's crop has been harvested.
c. If done at this period it is easy to distinguish the fruiting wood from that which has grown during the season, and by taking

out all the useless wood at this time the whole energy of the root is reserved for the new growth which is to supply the crop next season.

d. A cutting edge is provided on the hook which reduces it to a hawk-bill knife, and as well upon the chisel-shaped portion upon the back.

e. In one case the implement serves the purpose of a brush hook on a small scale, and in the other, when the chisel blade is used, it serves as a spud.

Fig. 129, Shows raspberry properly pruned.

4: **Third step.**

a. A third step in the pruning is shortening the lateral branches which have developed from the headed-in shoot.

b. This work is usually done in the spring before or at blooming time, and is for the purpose of regulating the crop as well as reducing the wood so as to enable the cane more easily to support the fruit and to make the work of harvesting more easy.

5. **New growth from roots.**

a. From what has been stated it will have been inferred that the raspberry bears its fruit most abundantly upon wood one year of age, and that older wood is of little or no use and should be cut out for the good of the plant.

b. There are exceptions to the rule, for raspberries frequently bear a few fruits upon the new shoots which annually come up from the root of the plant when those shoots are allowed to grow unchecked; but as this forms a late or second crop and as it does not occur as a fixed habit of the plant but rather as a result of peculiar weather conditions, it is never taken into account in commercial raspberry culture.

6. **Results of pruning.**

a. The shortening of the shoots to 2 feet or less in height together with the thickening which follows, renders them able to support a crop of fruit without the aid of a trellis.

7. **Method of stalking.**

a. If the upright growing varieties are planted in hills they may be stalked to a single stake from four to six feet high, and the canes loosely but firmly fastened to the stake.

b. Another method is to have two stakes about eighteen inches apart at each hill with the idea of training the fruiting canes on one post and the growing canes on the other.

c. Where the plants are planted in a continuous row they may be supported by a wire trellis of two wires running from the posts.

d. One of the wires should run along the top of the posts and the other from eighteen to twenty-four inches from the top.

e. Another method is to put across arms about eighteen inches long, on a single line of posts about three feet from the ground running a wire at each end of the cross pieces.

f. Another set of cross pieces at the top of the posts with heavy (No. 10) wire staples should be fastened.
g. This forms a lateral support.
h. This latter (the four-wire support) makes also, an excellent support for the viney varieties.
i. By this system the growing canes can and should be kept from the fruiting ones, thus facilitating picking, harvesting and pruning.

8. **Method of growth.**
a. The canes of these plants are biennial.
b. The canes grow the first season, fruit the second, after which they die.
c. New ones grow up to take their place at the same time.
d. When the new canes of the black-cap and Antwerps have reached the height of three to four feet, they should be pinched back which will cause them to become stout and thick, and strong laterals to develop.
e. After the laterals are a foot or so long, they, in turn should be pinched back.
f. When suckers are numerous they should be cut away, leaving only enough to replenish the plant for next year.
g. Usually five or six years is the age of one of these plants.

9. References.
a. Washington Bulletin No. 18.

3. Currants-Gooseberries.

1. **Currants.**
a. In general, a currant bush should be composed of from five to eight stalks, stopped about 18 to 20 inches in height.
b. If the plants are vigorous, shoots stopped at this height will produce several lateral branches, thus forming a compact, broad-headed bush with a maximum expanse of bearing wood.
c. To grow currants in tree form all the grower has to do is to remove all the buds from the part of the layer or cutting that is put in the ground.
d. This prevents any growth shooting up from below the surface of the soil, hence no suckers are formed.

2. **Gooseberries.**
a. The gooseberry should be treated like currants, but will be found to require less heading-back, because its normal habit is to produce numerous side shoots rather than strong, upright ones.

3. The canes of the currant and gooseberry bear several times.
a. Only the first two or three crops are the best; after this the fruit deteriorates in size.
b. For this reason, it is necessary that a succession of strong, new canes be coming on all the time.
c. Then, as the older canes age, they should be cut out.
d. A good bush may be allowed from four to eight canes, the fewer of course, the larger the fruits.

4. References.
a. Washington Bulletins Nos. 25, 26.

ORNAMENTALS.

1. **Objects** in pruning ornamental trees and shrubs.
   a. To produce some desired form.
   b. To develop strong and uniform foliage.
   c. To produce flower buds.
2. **The important things** to remember in pruning flowering shrubs.
   a. Those flowering in spring usually flower from winter buds.
   b. Those flowering in summer or autumn from buds formed that season.
   c. It will be seen that winter pruning of the former cuts away flower buds.
   d. Heading-in, just as soon as the flowers fall encourages the growth of new shoots, with the formation of new buds which will bloom the following year.
   e. These shoots will form without the aid of the pruner, but when the bush begins to get crowded or old, it is advisable to prune or head in and then thin out.
3. Summer blooming trees or shrubs bear flowers on shoots grown the same season.
4. The flowers are not formed until growth begins.
5. These plants should be made to bear a profusion of strong spring and early growths.
6. To facilitate this it is necessary to prune in the fall, winter or early spring.
7. The best example of this is the roses.
8. Climbing and pillar roses need only the weak branches and tips shortened.
9. Other hardy varieties need heading back from one-third to two-thirds of their length, early in the spring.
10. All old wood should be entirely cut out leaving only the last year's shoots.
11. A cutting back after the June blooming will also encourage new growth with a second crop of flowers.
12. If the cutting back is too severe in the June pruning, there will be only vigorous, leafy shoots without flowers.
13. Do not cut back over one-third.
14. In trimming roses, prune strong growing varieties moderately; weak growing ones severely.
15. **The spring blooming flowers** should be pruned just after they flower.

Amelanchier
Amydalus
Asiatic Hydrangea
Azalea
Barbery
Cerasus
Deutzia
Flowering Crabs
Flowering Currants
Forsythia
Lenerica
Lilac
Magnolias
Mock Orange
Most Woody Spireas
Rhodedendron
Snowball
Syringas
Tamarix Africana
Tamarix Gallica
Viburnums, French and Asiatic
V. Lantan and V. Opulas
V. Arieties, V. Plicatum
Weigela
Wistaria

16. **The summer and autumn blooming plants** should be pruned in winter or early spring.

American Hydrangeas	Genista
Ceanethus	Hydrangea Paniculata
Clematis	Kersia
Cornus	Most roses
Fly Honeysuckle	True or Twining Honeysuckle

HEDGES.

1. **Form.**
   a. One of the best forms for a hedge which is to serve either as a fence, windbreak, or as an ornament is the pyramid.
2. **Shaping the hedge.**
   a. When the plants are first set out in line they should be pruned or shortened to within 2 or 3 inches of the ground and allowed to grow undisturbed during the first season.
   b. At the end of the yearly growth, the plants should again be pruned down to within 6 or 8 inches of the first pruning, and the side or horizontal growths being pruned within an inch of the main stem.
   c. During the growth of the second season the hedge may be partially shaped by an occasional pinching out of the points of stronger upright shoots, but preserving every shoot and leaf on the weaker side growth.
3. **Varieties of hedges.**
   a. Honey Locust which makes the best quick-growing protective hedges; big strong spines.
   b. Barberry which is low, spreading and showy.
   c. Japan Quince, which has the finest flower of all hedge plants.
   d. Privet which is the fastest growing hedge.
4. **Pruning evergreens.**
   a. Evergreens, such as the arbor vitae, require less labor in preparation or training and maintenance than deciduous plants, as most of them naturally assume a pyramidal form, and by a practice, based upon the principles already noted, good hedges can easily be produced.
   b. The main points are to keep the top of the hedge shaped to a point and allow the sides to expand sufficiently so that all parts of the hedge surface may be exposed to light.
   c. Very rarely will it be necessary to trim the growing hedge more than once a year and the best time for the work is just before the commencement of the growth in spring.
   d. When the hedge has attained a height of 5 feet, it should be about 3 feet wide at its base or at the surface of the ground and all pruning should be directed with a view to securing this form.

ORNAMENTAL TREES.

1. **Planting of seeds.**
   a. See Stratification.
2. **Time to plant.**
   a. It depends upon the conditions of the soil, and the weather that follows transplanting.
   b. Many trees may be planted at any time during their dormant or leafless period.

c. Early spring is generally the best time to transplant.

3. **Before planting.**
   a. See Apple.
4. **Setting the tree.**
   a. See Apple.
5. **Pruning the stem.**
   a. The tree should remain under the nursery culture till it has reached a height from 8 to 10 feet.
   b. It should be headed-back from 7 to 8 feet.
   c. The young limb grows in the direction to which it is pointed in an angle to the parent branch according to its variety; it deviates from this to the light in more or less short curves. Knowing these three facts, besides the fact that the strongest limbs grow from the top buds, we should never prune so the bud will point inward toward the center.

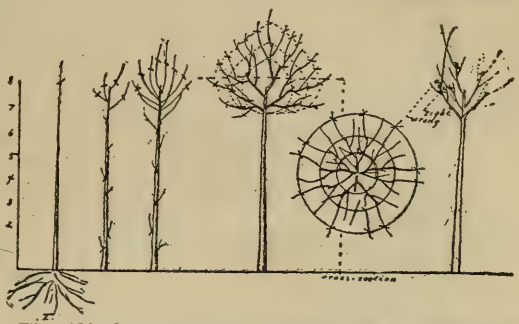


Fig. 120 shows how to prune the stems and tops.

   e. Practically the training process should commence in the nursery, where the growth of a leading shoot should be maintained and all side branches kept back by pinching their points.
   f. These branches should not be removed entirely, as they tend to strengthen the main stem, and can be removed later.
6. **Cutting branches.**
   a. Do not leave stubs or cut too close to trunks of trees.
   b. The cut should be as small as possible.
   c. Strong branches do not always develop from the highest cut.

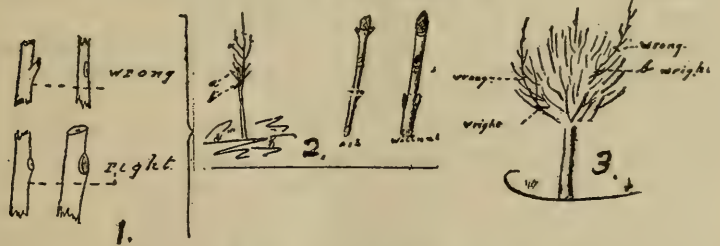


Fig. 131 shows the proper way to make cuts.

   d. No. 1 shows the cuts should be made smooth and not too close to bud.
   e. No. 2 shows where the strong bud developed and the strong terminal bud of the ash and walnut.
   f. No. 3 shows the right way to prune a rapidly grown branch.
7. **Main branches.**
   a. The young tree ought to have a crown of from 3 to 5 branches, and the lowest of which should be from 6 to 8 feet above the ground.

b. Keep in mind what the ideal tree looks like and the manner in which it is to be pruned.
c. Should the trees be planted in clusters or as specimen trees, in the park or on the lawn, of course it should not be headed nearly so high.
d. Remember the only beauty to be found in barren trunks of trees is when the lower limbs must be sacrificed for utility.
e. Since branches develop strongest from buds near the top, those which develop from buds lower down should be removed at the next pruning.
f. When five or six branches have developed to form a crown they should be headed-back about two-thirds of their length which is usually about two to two and one-half feet.
g. Naturally the length to cut them back will be influenced by the number of branches forming the crown.
h. The purpose of heading-back is to induce the tree to branch to such an extent as to form a wide crown.
i. Should too many limbs develop some may have to be taken out entirely.
j. Thus it will be seen that a young crown composed of three limbs would have to be headed-in shorter than a crown with five or six limbs.

8. **Forming the top.**

a. **Pruning at end of first year's growth.**
1. The exact length to head-back can not be specifically determined as it depends upon the variety and vigor of the tree.
2. A close observation by the pruner coupled with good judgment will result in the right heading-back.
3. A fairly safe rule to follow, is to cut off two-thirds of last year's growth for the first year.
4. After pruning, the tree will throw out numerous limbs, sufficient to keep the crown full but not crowd it too much.
5. Should a limb rub or cross, it should be cut out.
6. Should the crown be too open, then it should be headed-in.
7. Should the crown be too compact, then it should be headed-out.
8. The first pruning is to direct the growth of the young tree.

b. **Pruning at the end of second year's growth.**
1. Cut off about one-third of the last year's growth.
2. This pruning is to correct its development.
3. Not later than the second year after planting, a careful inspection should be made after the leaves fall, and if more than one shoot seems developing to leaders, select the fittest and remove the tops from the other; also cut the points of any side branches that appear to require checking, so as to maintain symmetry in the tree.
4. The idea should be to aid the tree in its natural form, never losing the esthetic effect a naturally developed plant must necessarily have upon the viewer.

c. **Pruning subsequent years.**
1. See second year.

2. The ordinary shade tree does not need pruning after the fourth year.
3. Should crowns be too full, branches should be taken out, but not in such a manner as to leave holes or unsightly places.
4. This may be done by cutting the branch back to a lower branch but not to the trunk.
5. Young trees that have strong terminal buds, as the chestnuts, ash, walnut, horse-chestnut, which represent the vitality of the limbs should not be treated by having the end of the limbs cut off as it will shorten their period of growth for four to five weeks and perhaps endanger the life of the tree itself.
6. If this type of trees develops a crown on one side, cut off the longer limbs entirely but do not head them back.
7. The ideal street tree is one having a straight, well defined central stem throughout its entire length, with side branches regularly disposed around it and sub-ordinate to it.
8. Trees grown in this shape will withstand fiercer storms and sudden bursts of wind without injury.
9. Not many deciduous trees naturally assume this form, but by timely pruning when young trees they can be greatly helped to approach it.
10. This training process should commence while the tree is young and its growth easily controlled.

9. **Symmetrical tree.**

a. The crown must extend horizontally from trunk in all directions.

b. This should mean that the cross-section would be circular with the trunk for the center.

c. If the trunk is the center of such a tree we have the ideal tree

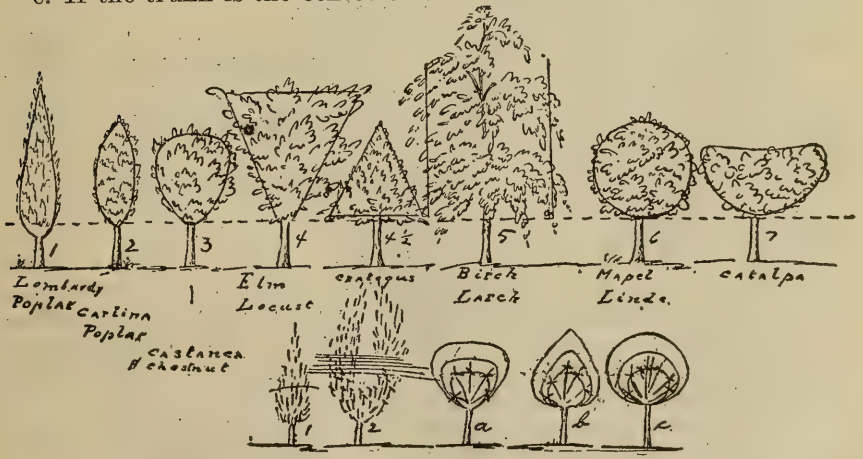


Fig. 132 indicates the habits in which different types of trees grow.

for the landscape, in fact any tree, either fruit or shade, for an ideal must be this way.

d. This applies to all trees regardless of their shape, or natural habit of growth, pyramidal, conical, cylindrical, depressed-conical, globe-shaped, erect, spreading, drooping or pendulous.

e. Fig. 132 illustrates seven types of trees with their respective natural shape.
f. Keep these shapes in mind as it is necessary to direct their growth.
g. Lower part of the above figure shows how to treat rank and out of proportion branches to keep the tree symmetrical.
h. Trees like type I (Lombardy) and 2 (Carolina poplars) forming an upright, undivided crown, may be started with branches five to six feet from the ground.
   1. Don't clip poplars over head.
   2. You can not change the habit of growth without distorting the crown and making it unsightly.
   3. Should telephone and telegraph wires necessitate it, then treat as 2 in lower cut.
   4. By reducing the center branches most of the side branches will be left longer and finally overtop the wire without touching them.
i. Type 4, Elm, as Black Honey Locusts may also be treated this way.
j. Trees like type 4, as an elm, which takes the form in its crown of an inverted pyramid, and those taking form of type 4½, the pyramid, should be pruned as indicated by a and b.
k. Trees like type 5, as birch and larch, starts in its early life to grow two main branches.
   1. If so, cut one of them back, giving the other a chance to forge ahead and become a leader, thus doing away with the danger of splitting.
   2. The same treatment should be applied to a Lombardy poplar.
   3. Avoid forks as they are weak places.
l. Trees like type 6, as various maples, Sycamore maple, English maple, soft maple, box elder, etc., with nearly globular crowns, should be pruned according to a and b.
m. Trees like type 7, as the linden, basswood, and the Catalpa grow according to c.
n. When it is not then the pruning must be severe enough to correct entirely.

10. **Lower branches.**

a. The removal of all lower branches is rendered necessary in order that they may not interfere with the proper use of the sidewalks and streets, but such removal has a tendency to weaken the main body of the tree and diminish its power of resistance against the sweeping blasts to which street trees are oftentimes subjected.
b. This trimming up from below will require attention for a number of years, because as the lower branches extend they will droop at the ends and become an interference.
c. The points of these drooping branches may be removed for a time but this will afford only temporary relief, and ultimately the whole branch will have to be removed by cutting it off close to the main stem; but this should not be done until it becomes absolutely necessary.

11. **Large trees.**
    a. The best method of pruning large trees in cities is sometimes a different question to decide.
    b. As a rule, the worst treatment they can receive is to cut off their tops "heading down" as it is termed.
    c. When this involves the removal of heavy branches, so as to leave a mere skeleton of stumps, it not only destroys the beauty of the tree but induces decay, especially with trees that do not speedily send out growth immediately below the cut.
    d. Heading-down is objectionable in so far as it causes a low, dense growth not desirable even as shade, and increases the liability to destruction from windstorms.
12. **General remarks.**
    a. In general, the pruning of shade trees is to be discouraged.
    b. It is only necessary, at the most, to prune them for a few years in order to get the crown properly balanced.
    c. Opening the top up as some do, is decidedly foolish.
    d. Topping old trees, thus leaving large, unsightly stubs for numerous watersprouts to grow from and form a thicket, is one of the rankest crimes committed against a tree.
    e. In general, after the first three years, a shade tree needs only to be pruned but a little merely as a correction to its shape.

Exercise 42.

1. **Object:** To estimate the height of a tree, "shadow method."
2. **Method:**
    a. Set a short pole in the earth near the tree so that the shadow of the pole will fall on ground the slope of which is as nearly as possible the same as that on which the shadow of the tree falls.
    b. Measure the height of the pole from the surface of the earth.
    c. The height of the tree may then be computed as follows:
    d. Multiply the length of the tree's shadow by the height of the pole, and divide the product by the length of the pole's shadow.
    e. The proportion may be expressed thus:
    f. The height of the pole is to the length of its shadow as the height of the tree is to the length of the shadow.

Exercise 43.

1. **Object:** To show where the increase in height takes place in trees.
2. **Method:**
    a. In the early spring find a vigorous tree, 2 feet or more in height with smooth bark, such as a young hickory, box elder, or cottonwood.
    b. Cut a notch in the bark at a given height above the ground and another notch about a foot above the first.
    c. Record the exact height of the first notch and the distance between it and the second.
    d. Now measure the height of the sapling to the topmost terminal bud.

e. Return to the sapling in the autumn and repeat the measurements.
f. How much has the tree increased in height?
g. Has either notch been lifted from the ground?
h. Have the notches grown farther apart?
i. Where has the new growth taken place?
j. Do you think that the tree in growing pushes its whole trunk upward, stretches that part already built or merely adds to its height at the top?
k. After a branch has developed from the trunk, would it be lifted higher from the ground by the growth of the tree?

Exercise 44.

1. **Object:** To show how a tree increases in diameter.
2. **Method:**
   a. Early in the spring select a young, vigorously growing tree, 3 to 4 inches in diameter, with a thin bark which peels easily, for example, a willow or box elder tree.
   b. With a sharp knife make a horizontal cut through the bark about one inch long.
   c. From each end of this cut make a vertical slit extending upward about 1½ inches.
   d. Carefully peel back the flap of bark thus loosened (being sure to expose the sapwood) and place a thin sheet of tinfoil beneath the bark on the exposed surface of the wood.
   e. Turn the bark into its place and seal up the incision with grafting wax.
   f. Examine the tinfoil at the close of the growing season.
   g. Has the deposit of new wood appeared in this instance on the inside or the outside of the tinfoil?
   h. Which part, then, builds the tree—the cambium layer or the sapwood?
   i. How thick is the layer of wood built this season?

13. **References.**
   a. See reference under laying out an orchard.
   b. Washington Bulletin No. 90.
   c. Minnesota Bulletin No. 96.
   d. Send to the Washington Nursery Co., Toppenish, Wash., for their complete descriptive catalogue.

WEATHER.

1. **Relation of weather to crops.**
   a. Effect of temperature.
   b. Effect of temperature on blossoms and matured fruit.
   c. Evaporation and radiation cause temperature of plants to be lower than elsewhere.
   d. Variation between day and night is from 4° to 8°.
   e. Effect of irrigation on the temperature.
2. **Effect of direct sunshine.** Fig. 178.
   a. Injury to the tissue.
   b. Injury to the leaves.
   c. Injury to the stem and trunk.
   d. Trees of heavy foliage.
      1. Protects the stem or trunk.

2. Protects the roots.
3. Protects the crop.

e. The difference between the temperature of the soil and of objects in direct sunshine and of soil and of objects in shade, is greater than the difference between the temperature of the atmosphere over or about the exposed objects and that over or about the shaded objects.

f. Shutting off or admitting sunlight has what effect upon plants?

3. **Effect of humidity.**
   a. Effect of low humidity on crops.
   b. Effect of high humidity on crops.
4. **Effect of local rainfall.**
   a. Effect depends on humidity.
   b. Effect depends on irrigation.
5. **Effect of winds.**
   a. Effect on moisture.
6. **Weather maps.**
   a. Secure maps from U. S. Weather Bureau.
   b. Trace the storm.
7. The force and direction of the wind should always receive equal consideration.
8. The different kinds of clouds and what each indicates should have considerable consideration.

Dew and Frost.

1. **Dew.**
   a. Plants usually receive more heat from the sun during the day than they give off; but at night the plants give off more heat than they receive.
   b. The atmosphere is capable of holding a certain quantity of vapor for any assigned temperature.
   c. There is a minimum temperature at which the vapor can be suspended in the atmosphere.
   d. This minimum temperature is called the dew-point, or the dew-point is when the air contains as much vapor as it is capable of holding.
   e. Dew is generally the vapor that falls in the evening, either visible or invisible.
   f. If the temperature falls below the dew-point, the vapor that can be no longer held in suspension is deposited on the surface of the earth or objects as, dew.
   g. The temperature of the dew-point must be above 32° if the vapor falls as dew.
   h. **Deposits of dew.**
      1. More dew is deposited on some objects than others because some objects radiate heat more rapidly than others.
      2. More dew is deposited during a clear night than a cloudy one.
         a. Objects cool more rapidly during a clear night.
         b. The clouds act as a blanket to the earth and prevent it losing heat.
      3. More dew is deposited during a still night than a windy one.
         a. Air must remain long enough in contact with cold objects to lower its temperature.

b. Powerful winds prevent the contact of the air with objects.
c. The cold air at the surface is not mixed with the warm air above.

2. **Frost.**
   a. When the objects are colder than 32° the dew is deposited as frost.
   b. When the surface of the plant has lost sufficient heat to cause its temperature to fall to 32° or below, frost is formed.
   c. When the dew-point is 10° or more above the frost point, 32°, a frost is not likely to occur; but if the dew-point approaches 32° frost is likely to occur.
   d. **Prediction of frost.**
      1. Clear nights.
      2. Still nights.
      3. Dry atmosphere.
      4. Changes of temperature accompany changes in barometric pressure.
      5. Dew-point reaches 32°.
      6. Study Weather Bureau Bulletins.
   e. **Barometric pressure.**
      1. It is determined by aneroid barometer which costs about $18 to $20.
      2. It indicates the air pressure and the highs and lows which may be seen marked on weather maps.
      3. High pressure is an indication of frost and low pressure which means that there is a considerable quantity of water vapor in the atmosphere, frosts are not so likely to appear.

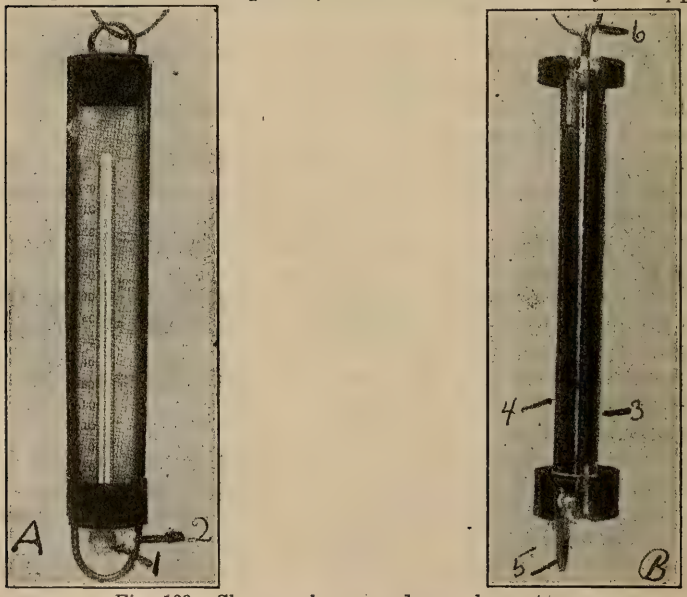


Fig. 133.—Shows a home-made psychrometer.
A, shows the arrangement of wet bulb; 1, the bulb of the thermometer is dropped below the frame in order to wrap with thin muslin; 2, the heavy wire to protect the bulb; B shows the two thermometers soldered together; 3, the dry thermometer; 4, wet thermometer; 5, heavy wire loop; 6, a string tied to ring serves as a mean with which to whirl the psychrometer.

4. Aneroid barometer indicates the high and low pressure and acts as a check on the psychrometer observation.

f. **Measurement of atmospheric moisture.**

1. General method is to observe the temperature of evaporation.
2. This method is determined by the difference between the temperature indicated by wet and dry bulb thermometers.
3. Sling psychrometer is the most reliable instrument.
   a. The muslin is first tied around the bulb at top then a loop of thread is formed around the bottom of the bulb thus drawing the muslin tight over the bulb.
   b. The wet bulb must be thoroughly saturated with water by dipping it into a small cup or wide-mouthed bottle.
   c. The psychrometer is whirled rapidly for 15 to 20 seconds; stopped and quickly read, the wet bulb first.
   d. This is repeated until two successive readings of the wet bulb are found to agree very closely.
   e. A good psychrometer costs about $4 to $5.

Exercise 45.

1. **Object:** To find dew-point.
2. **Method:**
   a. Hang psychrometer on a wooden frame in the shade and open air, from four to five feet above the ground.
   b. Cover the bulb of the wet thermometer with a thin piece of muslin cloth, fastening it securely with thread around the bulb. Fig. 133A.
   c. When this cloth is wet with water and exposed to the air it constitutes the "wet bulb" thermometer.
   d. Whirl or fan the "wet bulb" thermometer until the temperature ceases to fall and two successive readings are the same.
   e. Quickly compare the temperature of the two thermometers.
   f. For example:
      1. Dry bulb thermometer.... 50°
      2. Wet bulb thermometer.... 40°
      3. Difference ..... 10°
   g. Dew-point from table..... 25°
   h. Find dew-point in the following table.
      1. Read down the left column which shows difference in temperature between the two thermometers.
      2. Then read across to the column under the temperature of dry thermometer.

g. **Dew-point table** from Oregon Bulletin No. 111.

Difference of reading of dry and wet bulbs.	Temperature of Air—Fahrenheit.											
	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
1	11	16	22	27	32	38	43	48	53	58	63	69
2	6	12	18	24	30	35	41	46	52	57	62	67
3	..	7	14	21	27	33	39	44	50	55	60	66
4	..	1	10	17	24	30	36	42	48	53	59	64
5	..	..	4	13	20	27	33	40	46	51	57	62
6	..	..	..	7	16	24	30	37	43	49	55	61
7	..	..	..	1	11	20	27	34	41	47	53	59
8	..	..	..	..	5	16	24	31	39	45	51	57
9	..	..	..	..	..	11	20	28	36	43	49	55
10	..	..	..	..	..	4	16	25	33	40	47	53
11	..	..	..	..	..	..	11	21	30	38	45	51
12	..	..	..	..	..	..	4	17	27	35	42	47
13	..	..	..	..	..	..	..	11	23	32	40	47
14	..	..	..	..	..	..	..	5	18	28	37	45
15	..	..	..	..	..	..	..	..	12	24	34	42

h. **Effect of frost.**

1. Frost russet.
   a. It appears as a band about the center of fruit or at either the calyx or stem end of the mature fruit.
   b. It may be distributed over the entire surface of the pear.
2. **Frost blister.**
   a. It is an injury to the foliage causing the leaves to crinkle and crack.
3. **Injury to buds.**
   a. Sometimes buds are killed before they open, but they will shed their petals.
   b. Discoloration of the pistil when the flower buds are swollen.
4. **Injury to blossom.**
   a. Flowers injured after fertilization may develop and mature fruit.
   b. Discoloration of the basal part of the pistil of a plum, peach, or cherry seldom sets fruit.
   c. Discoloration may show in the minute apple seed and the fruit will develop to maturity if previously fertilized.
   d. The apple blossoms that show injury outside of seed cavities do not mature fruit.
   e. The yellowing of the tissues about the stem end of the blossom is the first indication of fatal injury.
5. **Injury to young fruit.**
   a. Discoloration and injury within the pit cavity of the stone fruit cause the fruit to fall at the beginning of the ripening period.
   b. Apples frozen after the blossom has fallen proves fatal.
6. **Destruction of the fruit bloom causes**
   a. Second crop bloom of the apple and the pear.
      1. First type of second crop bloom.
         a. Springs from the axil of leaf and will produce ma-

ture fruit; but is later and requires extension of time to ripen.

2. Second type of second crop bloom.
   a. Springs from the fruit spurs from large limbs or tree trunks; this type of growth seems to terminate the growth of a watersprout.
3. Third type of second crop bloom.
   a. Springs from axillary fruit buds which develop when the earlier bloom is destroyed.
   b. This type of fruit is produced from previous season's growth.
   c. Fruit is often produced from axillary buds when other blooms are not killed.

i. **Prevention of frost.**

1. Mulching prevents the radiation of heat from the ground.
2. Irrigation checks the radiation of heat from the surface of the ground; it should be used only as the last resort to prevent light frost in orchards.
3. Irrigation is an efficient means of protection for strawberries and any garden crops.
4. **Smudging.**
   a. It is to protect the trees from the early morning sun where some slight freezing of the blossoms and the fruit has occurred during the night.
   b. Smudges cause a dense smoke which acts like a cloud over the surface of the fruit.
   c. The cold draws the sap from the blossom and forms it into frost and the dense smoke keeps the sun from the blossoms until the temperature rises and melts the frost and the moisture is returned to the blossom.
5. **Heating.**
   a. Heating is to maintain the temperature and not raise it.
   b. The danger period is from the first swelling of the buds in the spring until danger is past; period of from 4 to 6 weeks when different varieties are in the same orchard.
   c. The best time to start fires is when the temperature is at 33° to 34°.
   d. Each orchard should be provided with several thermometers.
   e. The critical time is usually just before sunrise in the morning.

Exercise 46.

1. **Object:** To show the action of frost on soils.
2. **Method:**
   a. Puddle a pint of stiff clay, mold it into a ball, and bake it on the stove.
   b. In freezing weather moisten this ball and put it out of doors over night.
   c. If it does not break up the first night, moisten it again and subject it to the action of the frost.
   d. What happens?
   e. From this result what would you say of the practice of fall plowing?

f. Is there advantage of fall plowing aside from the action of the frost on the soil?

3. **References.**
   a. Fruit Growing by Bailey.
   b. Fruit Growing by Paddock and Whipple.
   c. U. S. Dept. Bulletin No. 401.
   d. Nevada Bulletin No. 79.
   e. Indiana Bulletin No. 154.
   f. Iowa Bulletin No. 129.
   g. Orchard Heating by B. E. Burley, Salt Lake City.

STUDY OF INSECTS.

1. **Apparatus needed** for the study of insects.
   a. Nets, cyanide bottles and a few empty bottles are needed in collecting insects.
   b. The net may be made by bending a heavy wire into a circle about a foot in diameter, turning the ends of the wire out and fastening into the end of a broomstick.
   c. Take a cheese-cloth sack a yard long and rounded to a point and sew onto the circular wire.
   d. The cyanide bottle for killing insects may be a wide-mouthed bottle, holding about one pint.
   e. Put in a few pieces of potassium cyanide and cover this with a layer of plaster of Paris.
   f. Thoroughly moisten the plaster and let set until it sets solid.
   g. Remove the surplus water and let the bottle become completely dry before using.
   h. Keep the bottle tightly corked and label **POISON.**
   i. Breeding-jars for rearing insects should be prepared before the insects are collected.
   j. Mason fruit jars with about two inches of moistened sand in them, are good.
   k. Cheese-cloth or mosquito netting with closed tops held in place by rubber bands are good.

Ar-throp'-o-da.

1. The injurious insects belong to the branch arthropoda.
2. The features that distinguish this group from all invertebrates is the presence of jointed legs.
3. **Classification of insects.**
   a. **Group 1.**
      1. This includes all insects in that stage of development in which their mouth parts are formed for biting.
      2. These insects bite off and chew, and swallow the portions of the plant upon which they feed.
      3. Most of these are killed by poison.
      4. Examples of these are grasshopper, beetles, caterpillars, larva of the codling moth.
   b. **Group 2.**
      1. This includes all insects in that stage of development in which their mouth parts are formed for sucking.
      2. These insects obtain their food by thrusting their beaks into the surface of the plant and feed by sucking the juice.

3. For this reason, any poison placed upon the surface of the plant does not affect them.
4. These must be killed by some contact spray as kerosene emulsion, tobacco leaf, or sulphur-lime.
5. Examples of these insects are plant-lice, scale insects, etc.

c. **Group 3.**
1. Insects that work in the wood of the tree.
2. This class belongs to the class of chewing insects.
3. They vary in their habits and must be considered in the light of its own history.
4. They tunnel just under the bark and can be easily located by the discoloration of the bark.
5. Example of these insects is the borers.

d. **Group 4.**
1. Insects that attach themselves to the roots.
2. This class belongs to the class of sucking insects.
3. Examples of these are woolly aphis, and root louse of the grape.

e. **Group 5. Parasites.**
1. The most important factors in checking the spread of insects are the numerous parasites.
2. **Kind of parasites.**
   a. Animal parasites.
      1. The most common of these are the small wasps, two-winged flies that deposit their eggs in or on the eggs and larvæ of injurious insects.
   b. Vegetable parasites.
      1. Fungus diseases that will kill insects.
         a. Chinch bugs are killed by fungus disease.
         b. Cabbage worm is destroyed by the cabbage plusia.

f. **Group 6.**
1. Predacious insects search out and destroy their prey.
2. The praying mantis, tiger beetles, lady bugs, and some wasps, and dragon flies.

4. **Natural agencies that destroy insects.**
a. Heavy rains.
b. Change in temperature.
c. Winds.
d. Predaceous and parasite insects.
e. Fungus and bacterial diseases.

Exercise 47.

1. **Object:** To collect and classify the insects.
2. **Method:**
   a. Collect all the insects possible.
   b. Classify them and label each bottle.
   c. Note the different stage of development.
   d. Keep the same species in the same group.

Exercise 48.

1. **Object:** To study how to preserve specimens.
2. **Method:**
   a. Collect the insects.

b. Any live insect may be quickly killed by placing in a bottle of cyanide and corking the bottle.
c. Mount by sticking a slender needle through the middle of the insect.
d. Should any specimens be desired to be preserved in liquid, place them in a solution of formaldehyde, 40% with 19 parts water.
e. Insects may be preserved dry without any preservatives.

5. An outline to study the external anatomy of each insect.
a. Study the grasshopper first, as its parts are readily pointed out.
b. **The division of the insect.**
1. **The head.**
a. Antennæ (feelers).
b. Compound eyes.
c. Ocelli (simple eye).
d. Labrum (upper lip).
e. Mandibles (jaws).
f. Ligula (tongue).
g. Maxillæ.

Exercise 49.

1. **Object:** To locate the parts of the head.
2. **Method:**
a. Find the antennæ (feelers).
1. How many segments in each?
b. Find the compound eye.
1. Examine under a low power microscope.
2. What is the general shape of the facets of the eye?
3. In what direction can a grasshopper see?
c. How many ocelli or simple eyes do you find?
d. Find the upper lib or labrum—lift and remove it. Draw.
e. The parts exposed by the removal of the labrum is the true jaw or mandibles.
1. In what direction can you move them?
f. Point out the parts of the maxillæ.
1. Base segment.
2. Maxillary palpus (jointed appendage).
3. Blade (large thin plate).
4. Make a drawing of the maxillæ.
g. Look for the labial palpi attached to the labium.
1. How many segments in each palpus?
h. The maxillæ is just in front of the labium.
1. These each consist of three parts united at the base.
2. The outer one is the maxillary palpus.
3. The middle spoon-shaped piece, the galea.
4. The inner piece, the lacina or maxillæ proper.
i. Draw front view of the head, labeling all the parts.
3. **Thorax.**
a. Segments or somites.
1. Prothorax (near head).
2. Mesothorax (middle).
3. Metathorax (hind).
b. Parts of the segments or somites.
1. Tergum is the top part.
2. Sternum is the underneath part.
3. Plura is the side part.

Exercise 50.

1. **Object:** To study the parts of the thorax.
2. **Method:**
   a. Locate the segments of the thorax.
      1. Each segment bears a pair of legs.
      2. Numbers of appendages has each segment.
      3. Breathing pores.
   b. Draw the thorax, labeling each part.

c. **Legs.**

1. Parts—beginning next to the body.
   a. Coxa.
   b. Trochanter.
   c. Femur.
   d. Tibia.
   e. Tarsus.
   f. Claws.

Exercise 51.

1. **Object:** To locate each part of the leg.
2. **Method:**
   a. Remove one of the legs.
   b. Make a drawing of the leg, labeling each part.
   c. The direction which the legs extend from the body.
3. Questions.
   a. How do the first and second pair of legs differ from the third in size?
   b. What is the use of the hooks and pads?

d. **Wing.**

1. Note the wings on one side of the body while they are folded, and their position with reference to the body also with reference to each other.
2. Spread them out and compare as to size, shape, color, texture, and position.
3. Make drawings.

e. **Abdomen.**

1. **Somites.**
   a. There are eleven.
   d. The dorsal (upper) and ventral (under) part of each is composed of a single plate called the tergite or sternite.
   c. The sternite of the last three somites are wanting in the female.

Exercise 52.

1. **Object:** To locate the parts of the abdomen.
2. **Method:**
   a. How many abdominal segments do you find?
   b. Are the last three distinct?
   c. Look along the grooves on each side of the abdomen for spiracles.
   d. How many in each of these segments?
   e. In how many segments are they found?
   f. Catch a live grasshopper and watch it breathe.
   g. Do the walls of the abdomen move?
   h. How do the spiracles move?
   i. Find the ear membrane on the side of the first segment.
   j. Examine the end of the abdomen.

k. If it is blunt, and composed of two segment appendages, the specimen is a male.
l. The upper appendage is the cerci.
m. If the end of the abdomen is tapering and divided into four parts, the ovipositer, the specimen is the female.
n. Draw the abdomen showing all its parts.
o. Cut through the mouth beyond the esophagus into the crop, open it, and examine its contents.
p. See if you can tell what is the insect's food.

6. **Metamorphosis of insects.**
   a. Development without metamorphosis.
      1. The young insect just hatched from the egg is of the same form as the adult.
      2. These insects merely grow larger without any more marked changes; as spring-tails.
   b. **Metamorphosis incomplete.**
      1. The young insect just hatched from the egg greatly resembles the adult.
      2. The young insect undergoes a striking change of form during its life.
      3. The young insect never passes into a quiescent state similar to the chrysalis; as the locust.
      4. Nymph is the term applied to young insect.
   c. **Metamorphosis complete.**
      1. The young insect just hatched from the egg bears almost no resemblance in form to the adult.
      2. The young insect undergoes several stages before it reaches the adult stage.

7. **The different stages of complete metamorphosis.**
   a. The egg is the first stage.
   b. The larva is the second stage.
      1. This is the form hatched from the egg.
      2. The larvæ simply eat and grow.
      3. All molting to increase in size is done in this stage.
      4. But later molts are to change shape.
   c. Pupa is the third stage.
      1. This is a period of inaction when great changes go on within the body.
      2. The insect either remains in old larvæ skin or spins a case for itself.
      3. Different terms use:
         a. Chrysalis is a term applied to the pupa of a butterfly.
         b. Cocoons are terms applied to silken cases which are secreted by the larvæ themselves.
   d. The adult is the last stage.

Exercise 53.

1. **Object:** To study how insects are developed.
2. **Method:**
   a. Keep each insect in the breeding jar supplied with fresh food.

b. Watch each successive stage of the subsequent developments.
c. Make careful notes and drawings on each stage.
d. Does the insect eat the tissue or suck the juice of the plant?
e. How do you know?
f. How does it secure its food in each stage of its development?
g. Do any of the insects, either in the larval or adult stage, prey upon any other insects?

Exercise 54.

1. **Object:** To study the later forms of insects.
2. **Method:**
   a. If the student has access to a pond or stream, let him collect forms which pass through all their stages of development in the water.
   b. Let him take a quantity of mud and water in which the water forms are found together with the aquatic plants for food, to the laboratory and place the different species in breeding jars.
   c. Observe all the stages in their development.

Order Ac-a-ri'-na (mites).

1. They are not true insects having eight legs when adults.
2. The mode of life of the different members.
   a. Some are parasitic upon animals.
   b. Others infest living plants.
   c. Many feed upon dead animal or vegetable matter.
3. **Study external anatomy.**

a. **Brown Mites.**

1. **Stages of development.**
   a. **The egg.**
      1. The egg is tiny red, globular form.
      2. The eggs are laid on the trunk, limbs, and in the crotches of trees.
      3. The winter is spent in the egg stage and the eggs hatch when warm weather comes in the spring.
      4. The eggs begin to hatch shortly after the leaves come out.
   b. **Nymph.**
      1. The newly hatched mites have only three pairs of legs.
      2. They continue to grow and remain red until after they molt for the first time, when they are brownish or olive green.
      3. They have eight legs after the first molt which remain with them throughout life.
      4. They do not thrive in moisture.
   c. **Adult.** Fig. 134—1.
      1. They are brown except the legs and head, which have a reddish hue.
      2. They deposit their eggs in May, June and July.
2. **Nature and appearance of injury.**
   a. They injure the apple, peach, plum, cherry, pear trees by feeding upon the foliage.

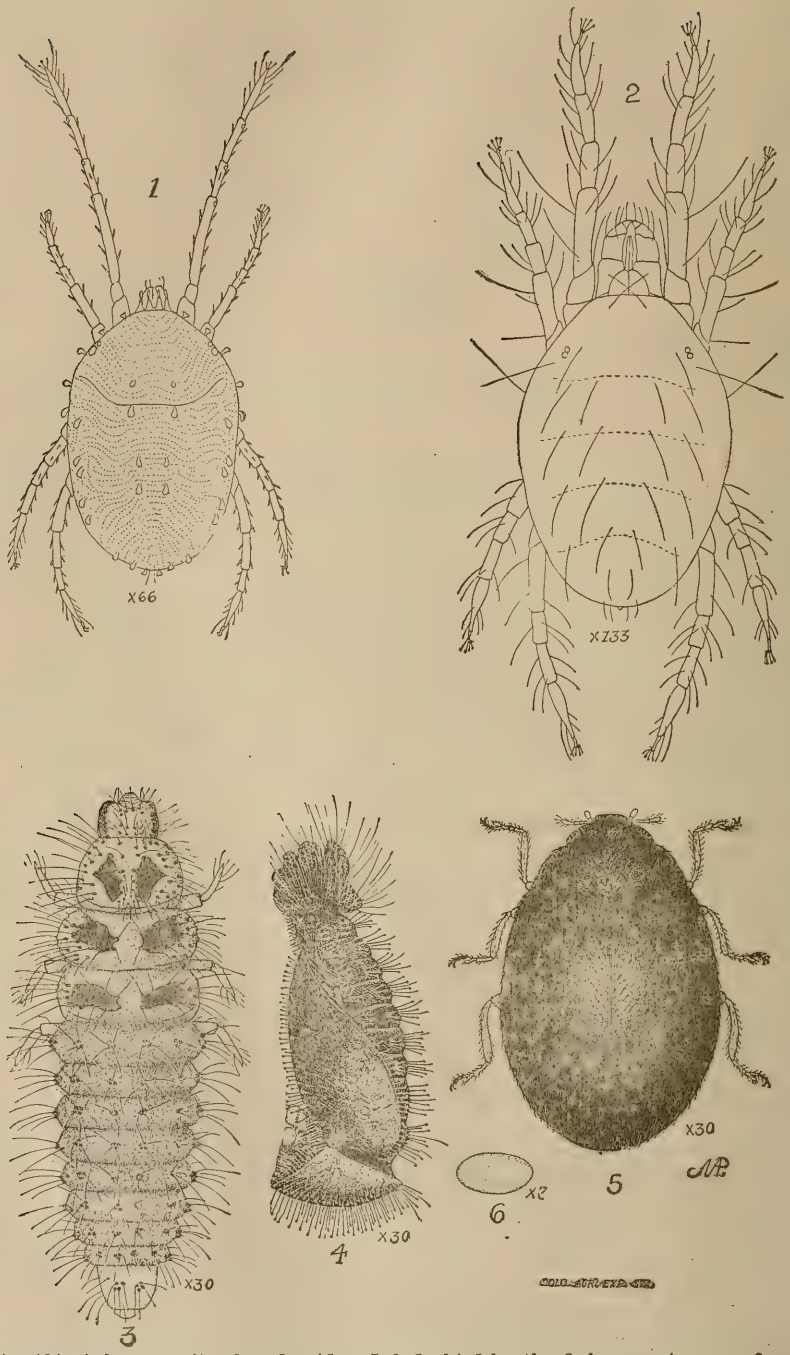


Fig. 134—1, brown mite; 2, red spider: 5, lady-bird beetle, 3, larvae, 4, pupa, 6, egg. (Colorado Exp. Station.)

b. They pierce through the epidermis of the leaf and suck out the sap.
c. The signs of infestation are the pallid leaves and tiny black spots of excreta.
d. Sometimes the foliage of the entire tree is covered, causing the leaves to turn yellow and drop off, thus weakening the vitality of the tree.
e. The fruit of a badly infected tree is small and does not mature properly.

b. **Red Spider.**

1. **Stages of development.** Fig 134—2.
   a. See brown mite.
   b. The species of red spider is light green, with small dark colored spots on the back when first hatched; and later turns to a deep brown or bright red.
   c. The adult spider hibernates in the winter and the few that survive crawl out and ascend the trees to deposit their eggs when spring opens.
2. **The nature and appearance of injury.**
   a. They injure both large and small fruit.
   b. The leaves of the infested tree are often yellow in spots which present a blister-like appearance.
   c. The leaves are sapped of their vitality, turn yellow and drop early.
   d. The fruit of an infested tree is small, often not maturing sufficiently to be salable.

c. **Blister mites.**

1. **Stages of development.**
   a. The egg.
      1. The eggs are laid in the spring in the gall on the leaves, from which the young mites are hatched.
   b. **Nymph.**
      1. The young mites hatch and grow to full size in the parent blister.
   c. **Adult.**
      1. They migrate to the younger leaves on terminal growth and produce other blisters.
      2. They are about 1/16 inch across and have four legs attached at the anterior end.
      3. They hibernate on the trees, generally under the bud scales.
2. **Damages.**
   a. They affect the leaves of the apple and pear trees.
   b. They burrow into the leaves from the under surface and feed on the tissue between the two surfaces.
   c. The blister or galls on the apple leaves are brown as they grow old, no coloration at first.
   d. The affected leaves shrink and the cells of the leaves are destroyed.

Order Or-thop'-te-ra (locust).

1. The insects have four straight wings.
2. the metamorphosis is incomplete.
3. The mouth parts are formed for biting.

4. Study the external anatomy of the grasshopper, as it is the easiest insect to study.
5. Study the cockroaches.
6. Study the thrips.
7. Study the praying mantis.

Order He-mip'-te-ra (bugs).

1. The winged insects of this order usually have four wings.
2. The metamorphosis is incomplete.
3. The mouth parts are formed for piercing and sucking.
4. Study the external anatomy.

a. **Apple Leaf Hopper.**

1. They are a tiny, active, greenish insect about an eighth of an inch long.
2. The metamorphosis is incomplete.
3. The hind legs are very slender and adapted to hopping.
4. Stages of development.
   a. Egg stage.
      1. The eggs are laid in bark of the trees and hatch soon after the buds burst in the spring.
      2. Some pass the winter in the egg stage.
   b. Nymph stage.
      1. The nymphs are very small and generally found on the under side of the leaves.
      2. The first generation appears about May and feed mostly on the old leaves.
      3. The second, third and fourth generations appear about the last of June, July and August.

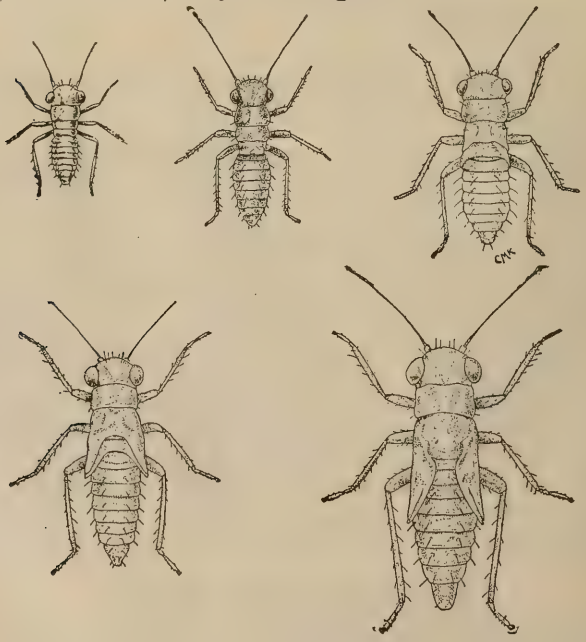


Fig. 135.—Shows the nymphs in their development. (Iowa Exp. Station.)

c. Adults.
   1. They are provided with wings.
   2. Some live through the winter, hiding away under dead leaves.
   3. They move very rapidly and are able to hop some distance.

5. **Damages.**
   a. They retard the growth of nursery stock and apple trees.
   b. They feed on the under side of the leaves causing them to curl.
   c. The new growth is checked and the leaves grow closer together and the tree fails to attain the size it should.

b. Grape Leaf Hopper.

1. See apple leaf hoppers.
2. They vary greatly in color, but the prevailing color is a light yellowish green.
3. The adults are very small, measuring about one-eighth of an inch in length.
4. The young resemble the adults and are green or yellowish green color.
5. **Damages.**
   a. See apple leaf hoppers.

c. Pear Psylla.

1. The adult is a four-winged insect measuring one-tenth of an inch in length.
2. **Stages of development.**
   a. Similar to the leaf hopper.
   b. The eggs are laid in the spring and hatch in a few days.
   c. There are a number of broods produced during the summer.
   d. The adults live through winter.
3. The larvæ or nymphs commence at once to suck the juice from the leaves.
4. The favorite place for young nymphs is in the axil of leaves and at the base of the fruit stems.
5. They occur in such a large number that entire pear orchards have been destroyed.
6. **Damages.**
   a. The sap is sucked out of the leaves and in some instances the tree killed.
   b. The trees become stunted and have an unhealthy appearance.
   c. The nymphs in a few days after hatching cover themselves with a honey dew which disfigures the tree and fruit.
   d. The honey dew becomes covered with a black mold and the leaves and fruit become disfigured.

d. Aphis, or plant lice.

1. **Stages of development.**
   a. **The sexual forms.**
      1. Generally on the setting in of cold weather, or lack of food if weather is warm, there is produced a generation of individuals of both sexes.
      2. The males are either winged or wingless.
      3. The females are wingless.
      4. The sexual forms pair and the female produces one or more true eggs called winter eggs.

5. The winter is passed either in the egg stage or adult stage.

b. **The egg stage.**
   1. The eggs hatch an agamic female when warm weather comes in the spring.
   2. Generally when the buds open in the spring.

c. **Agamic female.**
   1. She is the stock from which the summer generations spring.

d. **Spring generations.**
   1. **Wingless agamic forms.**
      a. They are females.
      b. Sometimes this form gives birth to living young instead of laying eggs, during hot weather, thus making the reproduction very rapid.
      c. From time to time young females reproduce which become winged.
   2. **Winged agamic forms.**
      a. They reproduce the wingless agamic forms.
      b. A single individual may fly to a new plant and start a new colony.
   3. The cycle is continued by sexual forms being reproduced in the fall.

e. The peculiar reproduction of the agamic form is often called budding.

f. There are about four generations each year.

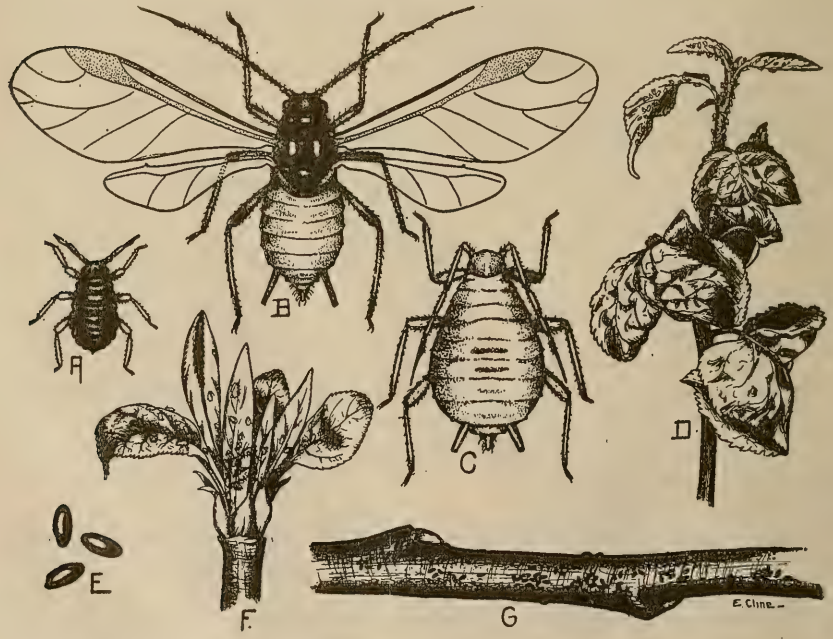


Fig. 136.—Shows Green Apple Aphis. A, stem mother just hatched from egg; B, winged female such as migrate from tree to tree during summer; C, wingless female of summer form; D, leaves curled by this aphis; E, eggs magnified; F, buds just opening, showing newly hatched eggs; G, Twig showing eggs as they appear in the winter time. (Montana Experiment Station.)

1. Green Apple Aphis.

1. This is a specie which is very small having a body only about one-fourth inch in length.
2. The winged aphis has two pair of delicate transparent wings.
3. There are both winged and wingless forms.
4. Stages of development.
   a. See aphis.
5. They secrete a clear liquid like honey dew which sticks to the leaves and twigs and finally turns black because of the black fungus which grows in it.
6. **Damages.**
   a. They injure the fruit of the apple, plum, pear, cherry and peach, etc.
   b. They attack the buds, leaves and twigs sucking the sap out of their tissues.
   c. They attack the blossoms and young fruit, causing several fruits to set on a single spur, but the fruit will not develop properly.
   d. They irritate the leaves causing them to curl.

2. Woolly Aphis.

1. They are very small, about the size of a pinhead.
2. They secrete from a gland opening on the back of the insect a woolly, waxy substance.
3. **Stages of development.**
   a. See aphis.
   b. Females both winged and wingless.

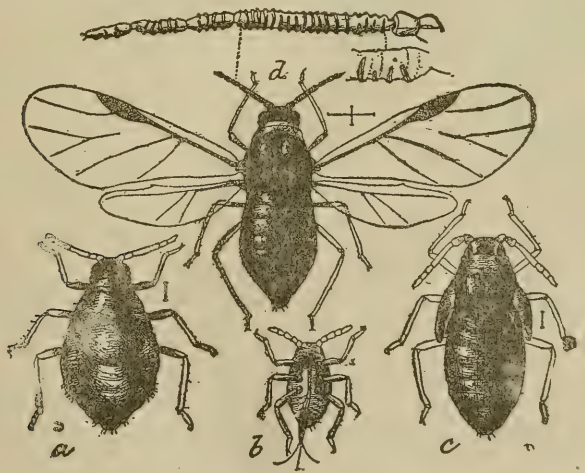


Fig. 137.—Woolly aphis. a, agamic female; b, larval louse; c, pupa; d, winged female with antenna enlarged above. All greatly enlarged with waxy excretion removed.

4. **Three sources.**
   a. A migration of part of the young lice from the roots to the limbs in the spring.
   b. A special hibernating form, which descend from the branches to the crown of the tree in the fall, ascend to the limbs in the spring.

c. A migration of winged forms which are produced in late summer or early fall and fly from tree to tree.
d. The last form gives birth to sexed individuals which pair and deposit eggs to hatch next season.

5. **Damages.**
   a. **The tree form.**
      1. This form is light brown.
      2. It is found on the trunk, limbs, of apple trees.
      3. It is very injurious to young trees affecting the bark which is made to swell when attached by the aphis.
      4. It is found in the axil of leaves and forks of branches.
   b. **The root form.**
      1. This form is dark brown.
      2. They live on dead roots for years; some are known to live for ten years on dead roots.
      3. The root forms are the same as the tree form which crawl down from the limbs.
      4. If the aphids are found on the limbs, it is safe to conclude that they are also on the roots.
      5. It is found on the fibrous roots, causing gall knots or swelling.
   c. The forms are easily recognized by the blueish-white cottony substance which cover the bodies.
   d. They are found on grafts and watersprouts.

3. Black Peach Aphis.

1. **Stages of development.**
   a. See aphis.
2. The young are of a faint greenish brown color, when they reach the adult stage they are black.
3. Similar to woolly aphis.
4. **The two forms.**
   a. The winged form.
   b. The wingless form.
5. **The tree form.**
   a. The winged aphids affect the tender shoots and leaves.
   b. Wingless aphids affect the leaves.
6. **The root forms.**
   a. The wingless aphis affect the roots.
   b. They migrate from the roots to the limbs in the spring.
   c. They breed continuously during the season except during hibernation.
   d. They cause knots to form on the roots.
7. When the tree is badly infested, the foliage has a yellowish green, sickly appearance; the leaves become curled at the edges and blotch.

4. Grape Phylloxera.

1. Stages of development.
   a. See aphis.
2. **Damages.**
   a. There appear upon the lower surface of the leaves fleshy swellings which are more or less wrinkled and hairy; these are hollow galls, opening upon the upper surface of the leaf and containing a wingless plant louse and her eggs.

b. They cause the roots to become swollen and knotty and sometimes decayed.
c. There are found in these swellings agamic wingless egg-laying aphis.
d. They affect young grafted stock.
e. The entire plant is often killed by the aphis.

e. SCALE INSECTS.

1. San Jose Scale.

1. The insect is concealed under a hard scale which is secreted by the insect.
2. Matured scales are about a sixteenth of an inch in diameter.
3. **Stages of development.**
   a. There is no egg stage.
   b. The adult female gives birth to living young about April.
   c. The winter is passed in half-grown state by both sexes.
   d. There will be found under the female a flat insect which has no legs, wings, eyes or antennæ, but will have a long, thread-like proboscis.
   e. **Larva.**
      1. The larva emerges from under the scale and crawls about over the branches for a short time before settling.

Fig. 138—San Jose Scale.
a, the larva from below; b, larva just set and waxy filaments beginning to appear; c, larva round, convex, waxy filaments are ready to coalesce; d, white scale just formed from above and side.

      2. On settling, the larva inserts its sucking proboscis into the bark to the sap beneath.
      3. The larva begins to secrete the scale for a covering over its body. Fig. 138, c.
      4. **Molting periods of the female.**
         a. **Fluffy stage.**
            1. It is from birth to first molt about 12 days.
            2. It is due to the secretion of cottony threads.
         b. **Tufted stage.**
            1. It is from first molt to second molt, from 6 to 8 days.
            2. It is due to the secretion of a waxy thread.
         c. **Black stage.**
            1. It is from second molt to maturity, from 10 to 12 days.
            2. The scale becomes thicker and passes into the mature form.
         d. It takes about 30 days for the female to develop fully.
      5. The molting stages of the male are similar to the female but it only takes about 25 days from birth until a two-winged insect is developed. Fig. 143.

4. **Adult female.**
   a. It is an ashy gray color and almost round in outline.
   b. It shows in the center of the upper surface a prominence called the nipple, surrounded by a darker colored ring. Fig. 139.
   c. It matures in about five weeks and commences to give birth to living young, bringing forth from three to four hundred within a few weeks and then dies.
5. **Adult male.**
   a. The male differs from the female by being smaller, darker in color and nearly twice as long as wide.
   b. The nipple is at one end.
   c. The male develops into a tiny two-winged fly.
   d. See purple scale.
6. **Means of distribution.**
   a. By the birds.
   b. By insects.
   c. By wind.
   d. By nursery stock.

Fig. 139.—Shows San Jose scale on a pear and also an enlarged scale.

7. **Damages.**
   a. They affect the branches, leaves and fruit.
   b. They attack the deciduous fruit trees; shade and ornamental trees and shrubs.
   c. They suck the sap out of the tender leaves and bark.
   d. The bark of the trees becomes pitted and the regularity of the trees is altered.
   e. The growth of the tissues is arrested.
   f. The fruit becomes infested and not fit for market.
8. **Preventatives.**
   a. By killing the insect or larva.
   b. By destroying the eggs.
   c. By spraying before the larvæ or nymphs have in any way formed a protection.
   d. See spraying calendar.

2. Oyster Shell Scale.

1. The scale is slightly convex and usually curved in outline to resemble a miniature oyster shell.
2. **Stages of development.**
   a. **The egg stage.**
      1. The eggs are laid beneath the scale in the fall and hatch in the spring during April or May.
      2. The eggs are pearly white.
      3. The winter is passed in this stage.

b. **Larva stage.**
   1. Similar to the San Jose Scale.

3. **Adult female.**
   a. The full grown female is about an eighth of an inch in length.
   b. By lifting a scale, there may be seen a number of pearly white eggs during the winter.

4. **Adult male.**
   a. The covering of the male is shorter than the female and very little curved.
   b. The male develops into a tiny two-winged insect and appears in midsummer.
   c. See purple scale.

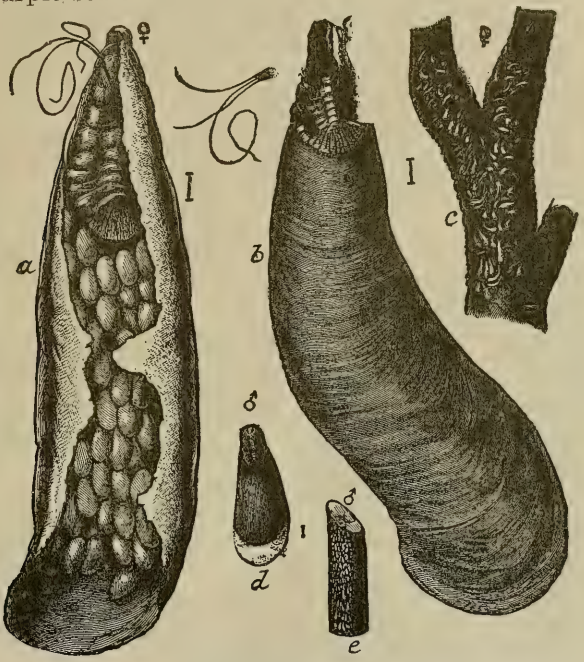


Fig. 140—Shows oyster shell scale: a, female scale from beneath filled with eggs; b, same from above; c, twig infested by female scale; d, male scale; e, twig infested.

5. **Means of distribution.**
   a. See San Jose scale.

6. **Damages.**
   a. See San Jose scale.

7. Preventatives.
   a. The winter egg should be destroyed.
   b. The young insects should be killed while they are crawling about.
   c. See spraying calendar.

3. Scurfy Scale.

1. **Stages of development.**
   a. **The egg stage.**
      1. The eggs are laid beneath the scale in the fall and hatch in the spring during April and May.

2. The eggs are purplish.
3. The winter is passed in this stage.

b. **Larva stage.**

1. Similar to the San Jose scale.

2. **Adult female.**

a. It is about one-tenth of an inch long and very flat and pear-shaped in outline.
b. The nipple is at the pointed end.
c. The color is light grayish or white, seldom pure white.

3. **Adult male.**

a. The male is pure white and smaller than the female and further differs by having parallel sides and three parallel ridges along the back.
b. They are found on twigs separated from the female.
c. They develop into a two-winged insect.

4. **Means of distribution.**

a. See San Jose scale.

5. **Damages.**

a. The injuries are insignificant compared with the San Jose scale.

6. **Preventatives.**

a. See San Jose scale.

4. Lecanium.

1. **Stages of development.**

a. The eggs are deposited beneath the scale-like body of the female.
b. The winter is passed either in the egg or young stage.

2. **Larva stage.**

a. Similar to the San Jose scale.

3. **Adult female.**

a. The wingless insect is about twice as long as wide and very small.
b. There is very little difference between the male and female until the second or third stage when the female emerges as an adult.
c. It takes several weeks before the egg laying organ is developed and the egg laying period lasts for several weeks.
d. The number of eggs laid by each female varies with the different species from 100 to 200.
e. It takes the female from 25 to 30 days to develop fully, depending upon the specie.

4. **Adult male.**

a. The stage of growth is similar to the purple scale.
b. The two-winged male differs very little from the purple scale. Fig. 143.

5. There are several species; as, the black scale, soft scale, and hemispherical scale.

6. **The hemispherical scale.**

a. It is lighter color, glossy surface, smaller than black scale.
b. It is easily killed by oil emulsion.

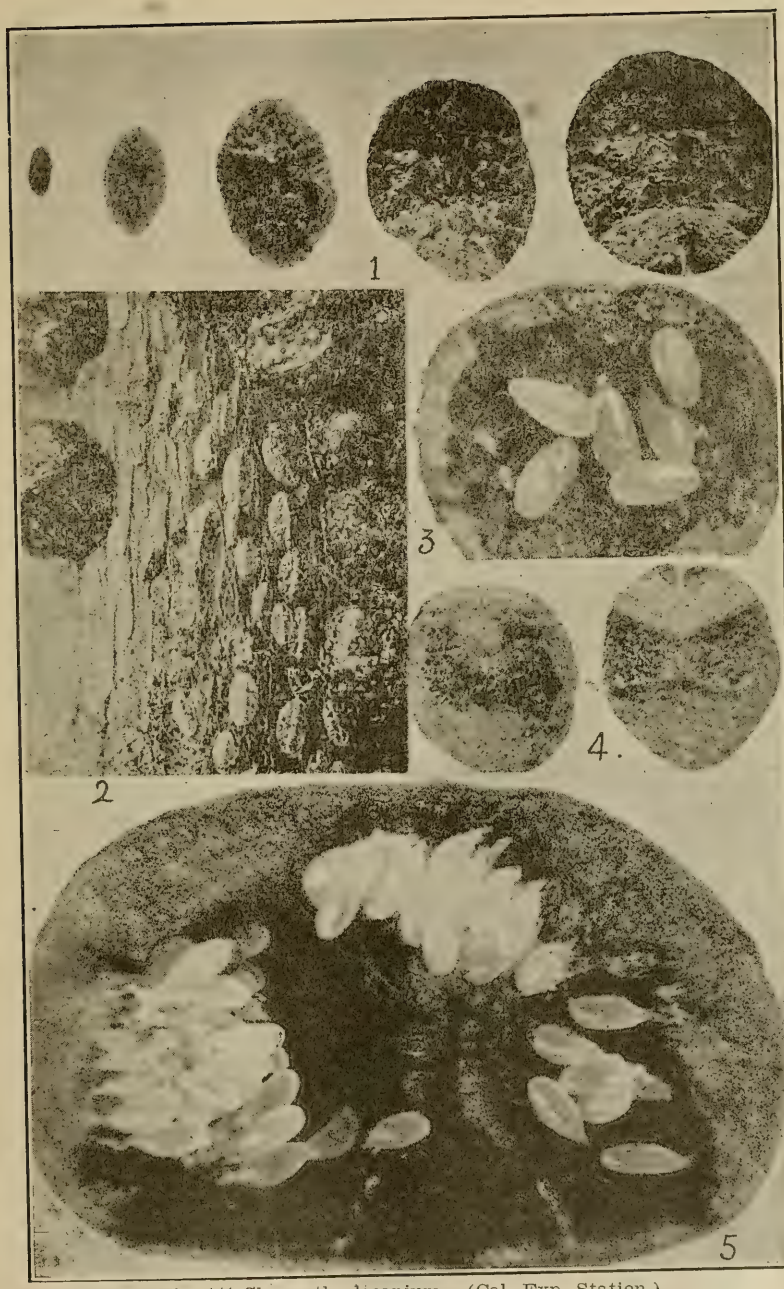


Fig. 141 Shows the lecanium. (Cal. Exp. Station.)

1. Shows the stages of growth of the black scale.
2. Shows how the scales attach themselves to the bark after settling.
3. Shows the eggs of Rhizobius ventralis under a black scale.
   a. The larva of which feed on the eggs, the young of the black scale before and after settling.
   b. It will also illustrate how coccinellid feed on the eggs and young of other scales.
4. Shows the hemispherical scale on left and black on the right.
5. Shows an inverted black scale with eggs of parasite of the scutellista.

7. **The brown scale.**
   a. It is flatter and lighter color than the black scale.

5. Purple.

1. **Stages of development.**
   a. Similar to Lecanium.
2. **Larva stage.**
   a. Similar to San Jose scale.
3. **Adult female.**
   a. Similar to Lecanium.
4. **Adult male.**
   a. The male is generally smaller than the female.

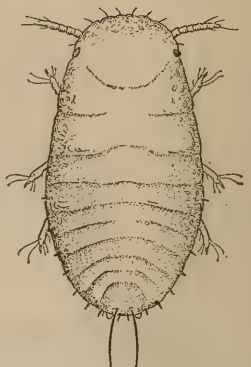


Fig. 142.—An active larva of purple scale.

Fig. 143.—Shows a purple male scale. (Cal. Exp. Station.)
1, second stage; 2, stage before pupa with the exuvium of the second state adhering to tip of body; 3, propupa; 4, pupa; 4, adult male X40.

b. It takes about 25 days for the male to develop from the scale form to a delicate two-winged insect.
c. The adult of the different species will differ in some of the recognition marks.

5. **Stages of molting of the purple scale.**
   a. The following cut will show in a general way the stages of development of the male insect.
   b. The appearance of the larva at different stages of development will differ according to the different kind of scales.
   c. The stages denote the molting periods of the male larva.
   d. Different scales will differ in their process of molting.

Order Neu-rop'-te-ra.

1. The insects have four wings.
2. The mouth parts are formed for biting.
3. The metamorphosis is complete.
4. The larvæ of the following feed upon other insects:
   a. Anti-lion feed upon ants and lice.
   b. Aphis-lion (lace-wing fly) feed upon plant lice and mites.
   c. Dragon flies feed upon mosquito larvæ.

Order Lep-i-dop'-te-ra (Butterflies).

1. The insect has four scale wings.
2. The metamorphosis is complete.
3. The mouth parts are formed for piercing and sucking.
4. Study the external anatomy.
5. Difference between butterflies and moths.

a. **Butterflies.**	b. **Moths.**
1. Day flying, usually.	1. Night flying, usually.
2. Wings erect when resting.	2. Wings sloping when resting.
3. Antennæ knobbed.	3. Antennæ not knobbed.
4. Pupa, chrysalid.	4. Pupa, often in a cocoon.
5. Larger.	5. Smaller.

a. Codling Moth.

1. **The moth** (g).
   a. The adult is rather variable in size, but the maximum wing expanse rarely exceeds three-fourths of an inch.
   b. The forewings above are of a brownish gray color, with numerous cross lines of gray.
   c. Near the top of each wing is a conspicuous brown spot, or ocellus, in which are two irregular broken lines of a metallic coppery or golden color.
   d. The hind wings above are grayish brown, becoming darker toward the margin, which bears a delicate fringe, at the base of which is a narrow line.
   e. When at rest on the grayish

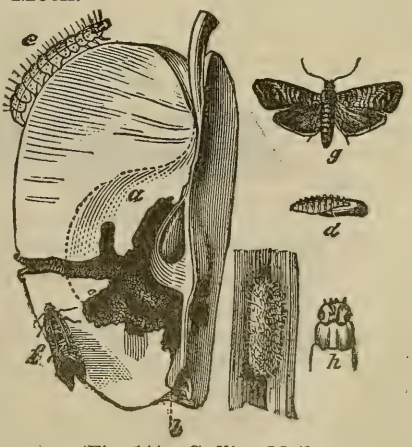


Fig. 144.—Codling Moth.
a, burrow in apple; b, entrance; d, pupa; e, large worm; f, moth closed wing; g, moth wings open; h, head of a larva; i, cocoon.

bark of an apple tree, the color of the moth so harmonizes with its surrounding that it is not readily distinguished.

f. Shortly after the moths leave their cocoons (i) the sexes mate and females begin to deposit eggs which are on the average of 50 eggs for each female moth.

g. The moth appears in the spring about two weeks or more after the beginning of the blooming period, or when about 80 per cent of the petals have fallen.

h. The moths mate and eggs are laid in a day or two which hatch in about 8 days.

2. **The egg.**

a. The eggs are small, flat, somewhat oval in shape and about the size of a pinhead.

b. When recently deposited they are of a pearl white color, but become darker with the development of the embryo, which, after a few days are easily distinguished as a reddish ring within the egg.

c. Under a lens the surface is seen to be covered with a network of ridges, coarser toward the edge.

d. The eggs are deposited on leaves, twigs, and blossom end of the apple.

3. **The larva** (e).

a. It is in the larval or "worm" stage that injury is done to the apple.

b. The larva as it hatches from the egg is very small, from one-twentieth to one-sixteenth of an inch in length, and it soon begins to search for food.

c. The larvæ chew more or less into the leaf or other portions of the plant in their wandering around.

d. The head is brown and well developed.

e. There are eight pairs of legs; three pairs of which are true legs, on the thorax, and five pairs of which are prolegs on the abdomen.

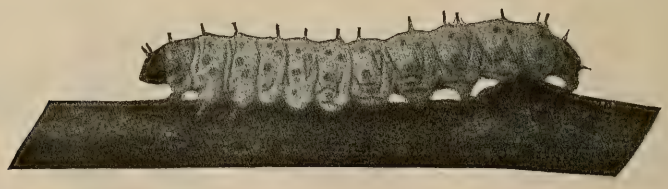


Fig. 145.—Shows a full grown larva, magnified.

f. When the codling worm emerges from its egg-shell it is small, delicate and hungry, and seeks for shelter and food in some dark place.

g. The blossom end of the apple provides both, and actually attracts about 80 per cent of the worms, whether early or late in the season.

h. That the majority of the coddling worms are instinctively directed to the calyx cavity is probably due to the absence of a tough skin and the presence of the nectaries at this place.

i. Some worms eat their way through the side of the fruit, even

though this part be covered with a woolly coat or with a tough skin.

j. Where two apples touch, or where a leaf overlaps an apple, the codling worm is apt to begin feeding.

k. After entering the apple the larva feeds and grows rapidly and in the course of about twenty days has become full grown and emerges from the apple.

l. At this time the insects are about three-fourths of an inch long, and the majority of them are pinkish or flesh colored on the upper surface and whitish below.

m. When ready to leave the fruit, the larva eats out a hole at the side, or less usually makes its exit by enlarging the entrance hole.

n. If the infested apple is hanging on the tree, the larva usually makes its way out to the limb and thence crawls down the branches to the trunk until a suitable place for pupation is found.

o. If the apple has fallen before the larva has gotten its growth, the latter simply crawls to a convenient place and there constructs a cocoon.

4. **The pupa** (d).

a. The full grown larva, upon leaving the fruit and finding a protected place, constructs a whitish silken cocoon (i) within which in the course of a few days it may change to a pupa.

b. The pupa is about one-half inch long, at first, yellowish or brown, but later becoming quite dark brown, and shortly before the emergence of the moth assuming a distinct bronze color.

c. This stage varies much in length, but on the average about twenty days elapse from the spinning of the cocoon until the emergence of the moth.

d. After emergence of the moths, in the course of a few days they begin egg laying, the entire life cycle from egg to egg requiring, on the average, some fifty days.

Exercise 55.

1. **Object:** To tell when the moth appears.
2. **First method:**
   a. Prepare a breeding cage by taking a wide-mouthed fruit jar and tie some light wire gauze over the mouth so that neither worm nor moth can get out; or
   b. Enclose an entire branch with gauze netting and also the moth should be caged within.
   c. All cages and bottles should be kept in the orchard and under a tree so as to be in conditions as natural as possible.
   d. Refer daily to your cage when the apples begin to blossom.
   e. Compare the emerging of the moth with the falling of the petals.
3. **Second method:**
   a. Band the trees with heavy strips of cloth or burlap.
   b. Fasten one of the cloths to the tree by driving a finishing nail in order that the other end may be attached to the

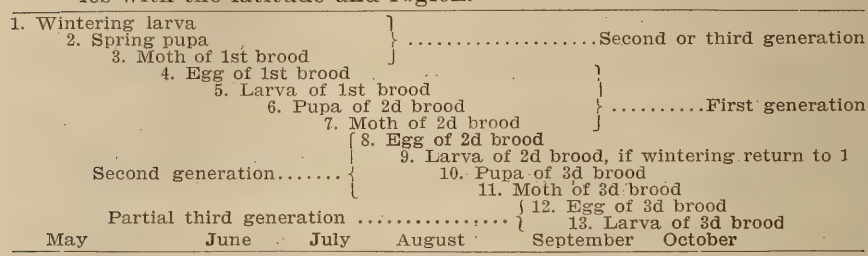
same nail, but make a fold in the cloth before wrapping the tree.

c. Examine the bands every 10 days as it only takes about 20 days for the larva to change to a moth.

d. Note: The above exercise will tell when to spray and also what effect the last spray had.

5. **The number of generations.**

a. The number of generations of the codling moth in a season varies with the latitude and region.



b. **Tabular form of the course** of development by Melander.

1. Study when the moths of the different broods appear.
2. Study when the larvæ of the different broods appear.
3. Study when the pupation of the different broods take place.

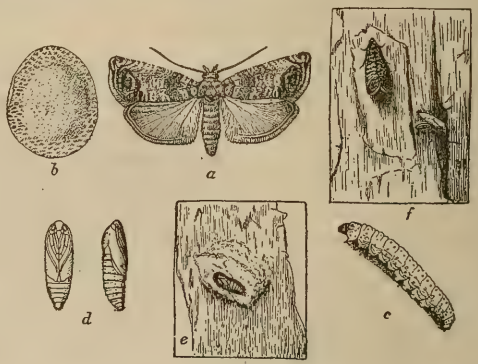


Fig. 146.—Life cycle of a codling moth. a, moth or adult; b, egg; c, larva; d, pupa; e, pupa in cocoon on inner side of piece of bark; f, moth on bark and empty pupa skin from which it emerged.

c. **Life cycle from egg to egg.**

1. From egg to larva 8 days.
2. From larva to pupa 19 days.
3. From pupa to moth 18 days.
4. From moth to middle of egg-laying 5 days.
5. Total of fifty days.

d. The wintering of larva: See above diagram, Nos. 1, 9 and 13.

1. In late summer or fall, larvæ will seek protected places upon the trees, as holes, cracks or crotches of limbs, or under bark scales, or even underneath trash on the ground, construct tough cocoons, and here pass the winter in the larval condition.
2. In the spring, the larvæ enter new cocoons or remodel winter cocoon and in about 18 days the moths emerge.

6. **Damages.**

a. They injure the fruit of the apple, pear, quince and English walnut.

b. The greater part of the life of the larva is spent within the fruit, during which period it feeds freely on the substance of

Fig. 147.—Section of a wormy apple; codling moth; larva.

the apple, eating out a cavity or tunnel and pushing out from the entrance hole a considerable quantity of powdery brown frass.

c. Most apples injured when small, as by larvæ of the first generation, drop from the trees, and these are a large percentage of the so-called windfalls.

d. Larvæ of the first generation will mostly enter the fruit at the blossom end, some, however, entering at the side, as where two fruits are in contact or where an apple is touched by a leaf.

e. Larvæ of the second generation enter the fruit more from the side than the calyx end, and by reason of their greatly increased numbers cause the larger part of the total injury. Fig. 147.

f. In localities where a third or partial third brood may occur, the habits of this generation are no doubt practically identical to those of the second.

b. Cutworms.

1. The cutworms are among the most troublesome insects with which the farmer has to deal.
2. The cutworms are "general feeders" and are able to find a living anywhere.
3. The cutworms are generally nocturnal, remaining hidden during the day concealed around the plants which they have destroyed during the previous night.
4. Most species are single-brooded northward, but many produce two or more broods southward.
5. Principal species.
   a. Greasy cutworm.
   b. Granulated cutworms.
   c. Fall army worm.
   d. Army worm.
   e. Variegated cutworms.

a. Variegated Cutworms.

1. The variegated cutworm is the most destructive and widely known of all cutworms.

2. **Stages of development.**
   a. **The egg.**
      1. The eggs are deposited often in large masses on grasses, weeds, leaves and twigs.
      2. The eggs hatch in from 10 to 12 days.
   b. **The larva.**
      1. The larva is about one and three-fourths inches in length.
      2. The larvæ feed on all parts of the plants.
      3. The larvæ of the variegated cutworms are climbing worms and when abundant assume the army worm habit.
      4. The larva is cosmopolitan in the broadest sense of the word in its feeding habits.

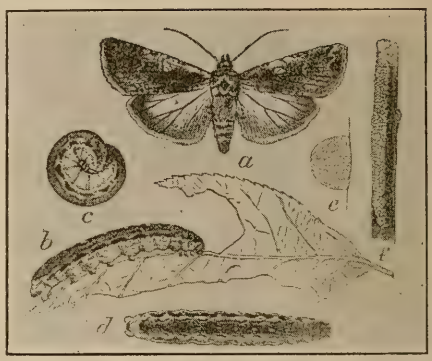


Fig. 148.—Variegated cutworm. a, adult; b, larva, sideview; c, same curled up; d, dark-colored larva; e, single egg; f, cluster of eggs on twig.

   c. **The pupa.**
      1. The larva having attained full growth enter the earth and construct a compact earthen cell or cocoon which is lined with a silken substance.
      2. The larva remains in pupal stage from three to six weeks before the moth appears.
   d. **Adult.**
      1. The adult is a large moth with pale, grayish-brown forewings tinged with reddish and shaded with darker brown.
      2. There is a considerable variability in markings, which is often suffused.
      3. The last appearing generation of moths issues from the ground in mid-summer or autumn and deposit eggs from which larvæ hatch and feed until cold weather drives them to their winter quarters.
   e. **Winter hibernation.**
      1. Some species pass the winter in the pupal condition.
      2. Some species pass the winter in the larva stage, which is generally the last appearing larva of the season and only half to three-quarters grown.
      3. Some species pass the winter in the adult stage.
3. **Damages.**
   a. The cutworms feed upon anything green and succulent, whether foliage, flowers, buds, fruit, stalks, tubers, or roots.
   b. The variegated cutworms are destructive to foliage of fruit trees and from their habits of climbing are known as climbing worms.

4. Preventatives.
   a. Poisoned bait.
   b. Bran arsenic mash.
   c. Bordeaux mixture.

c. Bud Moth.

1. Adult is very small, measuring about three-fourths of an inch across the wing.
2. Study the external anatomy.
3. Stages of development.
   a. The egg.
      1. The eggs are laid in June and July on the underside of the leaves.
      2. The eggs hatch in about 8 days and the larvæ feed on the under side of the leaves.
   b **The larva.**
      1. The larvæ protect themselves by a thin, silken web.
      2. They migrate before winter to the twigs and form the silken case in which they live during the winter.
      3. In the spring about the time the buds open, the larvæ come forth and bore into the buds, and as the leaves and flowers unfold, form nests by tying the leaves together.
      4. They do not leave their nests to feed.
      5. They become full grown during June.

Fig. 149.—Apple tree Bud Moth; a, moth; b, larva; c, pupa.

   c. **Pupa.**
      1. They pupate in the nest.
      2. They pupate in about 10 days, a small brown moth emerging.
      3. They begin to lay eggs for the next geenration.
   d. **Damages.**
      1. They injure the fruit of the apple, cherry, peach, pear, plum and quince.
      2. They destroy the foliage and eat into the fruit buds and leaf buds.
      3. Sometimes large trees are so severely injured that the fruit crop is almost destroyed.
4. Note: Study the following moths.
   a. Tiger moth.
   b. Tussock moth.
   c. White-marked Tussock moth.

f. Case-Bearers.

1. **Two species.**
   a. Pistil case-bearers.
   b. Cigar case-bearers.
   c. Their life history is similar.

2. **Stages of development.**
   a. **The egg.**
      1. The eggs of both species are deposited singly on the under sides of the leaves during May and June.
      2. They hatch in about 10 to 14 days.
   b. **The larvæ.**
      1. The larvæ feed on the tender pulp of the leaves.
      2. They migrate during September to the branches and twigs to remain until spring in their silken cases.
      3. They become active in the spring, feeding while they remain in their cases.
      4. They enlarge their silken cases as their growing bodies demand until about the middle of May, when they are ready to pupate.

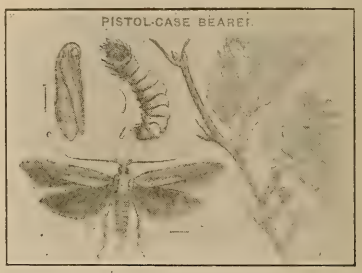


Fig. 150.—Pistol Case-Bearer; a, affected twigs and leaves; b, larva; c, cocoon; d, moth.

   c. **The pupa.**
      1. The case-bearers migrate to the twigs and attach themselves to the bark.
      2. They turn around in the case so that their heads will be toward the upper and curved ends.
      3. The pupation lasts about two weeks.
      4. The moths appear during May and June.
3. **Principal difference between the species.**
   a. The case of the cigar case-bearers is straight.
   b. The case of the pistol case-bearer resembles a pistol.
   c. The color of the cigar case-bearer is steel gray.
   d. The color of the pistol case-bearer is brown.
4. **Damages.**
   a. They effect the apple and pear trees.
   b. They attack the growing buds in the spring.
   c. They injure the leaves by feeding on the soft tissues.
   d. They attack the flower buds, flowers and fruit.

e. Spring Canker Worms.

1. **Stages of development.**
   a. **The egg.**
      1. The small oval eggs are laid in irregular bunches on the bark of main branches.
      2. The eggs hatch about the time that the leaf buds open.
   b. **The caterpillar, or larva.**
      1. The catterpillars have very small body and of olive green color.
      2. The caterpillars are about an inch long and have eight longitudinal bands.

3. Head and shield are shiny black.
4. They crawl to the ground when full grown to pupate.

c. **Pupa.**
1. The caterpillars go into the ground where they spin a silken cocoon.
2. They emerge in the spring, but sometimes in the fall and winter in pupation.

d. **The adult moths.**
1. The males have wings, while the females are wingless.
2. When the females emerge they ascend the tree to lay their eggs.
3. The flying season is in the spring.

Fig. 151.—Spring canker worm. a, male moth; b, female moth; c, joints of caterpillar; d, eggs.

Fig. 152.—Fall canker worm. a, male moth; b, female moth; c, joints of caterpillar; d, eggs.

f. Fall Canker Worm.

1. **Stages of development.** Fig. 152.
a. **The egg.**
1. The small irregular eggs are laid in regular masses on twigs and leaves in the fall.
2. They are hatched about the time the leaf buds open
b. **The caterpillar,** or larva.
1. The caterpillars are small and of a light green color.
2. They are about an inch long and have 6 longitudinal bands.
3. No abdominal spines.
4. They crawl to the ground when full grown to pupate.
c **Pupa.**
1. The caterpillars go into the ground, where they spin a silken cocoon.
2. They emerge in the fall as moths.
d. **The adult moths.**
1. The males have wings while the females are wingless.
2. The females ascend the trees to lay their eggs.
3. Few of the moths live through the winter.
4. The flying season is in the fall.
e. The females may be easily caught by banding the trees.
f. The caterpillars are commonly known as measuring worms, inch worms, or span worms.
g. **Damages.**
1. The caterpillars feed upon the tender leaves of the apple and the pear trees and some times defoliating them.

g. Green Fruit Worms.

1 **See bud moth.**
2. **Stages of development.**
a. **The egg.**
1. The eggs are laid in the spring and hatch in a few days.

b. **Larva.**

1. They are yellowish-green color with cream-colored markings and stripes down the back.
2. They are about one and one-half inches long when full grown.
3. They are most abundant in May.

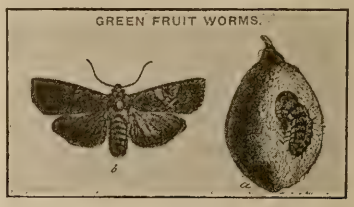


Fig. 153.—Green fruit worm; a, larva; b, moth.

c. Pupa.

1. When the larvæ are full grown, they go into the ground and spin a cocoon and pupate.

d. The adult moths.

1. They emerge from their cocoons as dull-colored moths, measuring about two inches from tip to tip of wings.
2. They remain over winter in some sheltered place, laying eggs in the spring.

3. **Damages.**

a. They affect the apples, pear, plum, peach and quince trees.
b. They feed upon young fruit.
c. They feed at night, resting on the under side of the leaves during the day.

h. Fall Web Worms.

1. **The moths** are of a pure white color.
2. Sometimes the wings are spotted with black.

3. **Stages of development.**

a. **The egg.**

1. The eggs are laid by the female during July, on leaves in masses of 400 to 500.
2. They are of a pale yellowish-green color.
3. They hatch in about 10 days.

b. **The larva or caterpillar.**

1. They seem to be almost all head and hair; commence to spin their web over the foliage.
2. The web extends over quite an area enclosing the foliage upon which they feed.

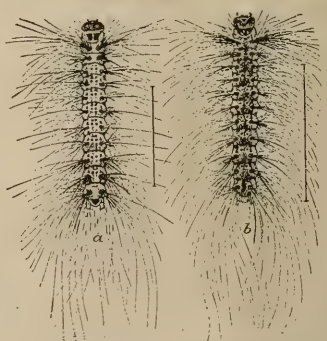


Fig. 154.—Fall web worm; a, b, caterpillar; c, cocoon; d, moth.

3. Within this web the colony from an egg mass feeds, enlarging it as it becomes necessary.
4. The caterpillars will leave their web and form a new web upon fresh foliage when the foliage within the old web is consumed.
5. The caterpillars are about one inch long and quite woolly.
6. The caterpillars molt about five times before pupation.

c. **Pupa.**
   1. The caterpillars find secluded places under bark, rubbish in fence corners, cracks of buildings, under eaves, surface of loose soil and sometimes in old cocoons.
   2. They spin their cocoons which are flimsy affairs.
   3. They shed their skin for the last time and then transform into moths.
   4. They pass the winter in pupa stage and emerge in June.

d. **The adult moths.**
   1. The moths lay their eggs in July.

4. **Damages.**
   a. They affect the foliage of the apple and pear trees.

i. **Apple Tree Tent Caterpillar.**

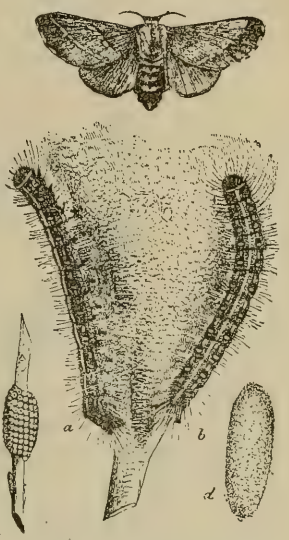


Fig. 155.—Apple tree tent caterpillar; a, b, caterpillar; c, egg mass; d. cocoon; e, moth.

1. **The moth** is brown, with two oblique parallel white lines on the forewings.
2. **Stages of development.**
   a. **The egg.**
      1. The eggs of each are laid in July in masses about the twigs.
      2. The eggs remain unhatched for about nine months.
      3. The eggs are covered with a substance which protects them during winter.
      4. The eggs hatch in early spring about the time the leaves appear.
   b. **Caterpillar,** or larva.
      1. They form a colony from each egg mass and spin a tent in which they stay when not feeding.
      2. They generally migrate down the branch until they find a good-sized fork to build a large tent, which is often 2 feet or more in length.
      3. They go out daily to feed; and spin a silken thread wherever they go.
      4. They spin thin cocoons in about five or six weeks after hatching.
   c. **Pupa.**
      1. The caterpillars, when full grown, find a sheltered place to spin cocoon and to pupate.
      2. It takes about three weeks for the pupation.
   d. **The adult moths.**
      1. They emerge in the latter part of June or early July.
      2. The females lay their eggs in July.
3. **Damages.**
   a. The young caterpillars feed upon the unopened buds until the leaves expand.
   b. The apple is greatly injured by the caterpillars.
4. Note: Study the following.
   a. The yellow-necked apple caterpillar.

b. The red-humped apple caterpillar.
c. Brown-tail moth.
d. Gypsy moth.

j. Peach tree borer.

1. **The adult moths** are a beautiful blue color.
2. **Stages of development.**
   a. **The egg.**
      1. They are laid on the bark of the trees near the ground during May and June.
      2. They are small, reddish and oval in shape.
      3. They hatch in from 9 to 10 days.
      4. Each female may lay from 200 to 800 eggs.
   b. **The larva.**
      1. The young at once seek cracks in the bark where they feed upon the sapwood during the remainder of the season.

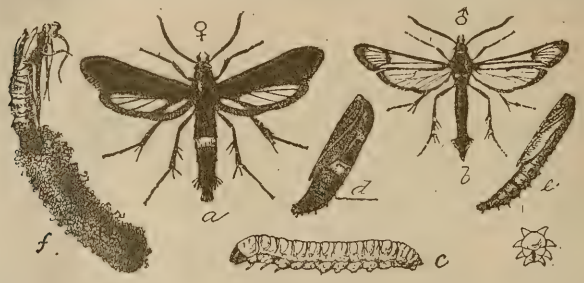


Fig. 156.—The peach tree borer. a, female moth; b, male moth; c, larva; d, female pupa; e, male pupa; f, pupa skin and cocoon.

      2. Their location is easily detected by the powdery light brownish frass that is pushed out from their burrow.
      3. They remain in this stage in the tree through the winter and feed again in the spring before they pupate.
   c. **Pupa.**
      1. The larvæ leave their burrows and construct cocoons at or near the surface of the ground on the trunk of trees or on the loose soil.
      2. The larvæ emerge from their cocoons in about 3 or 4 weeks as moths.
   d. The adult moths.
      1. The moths mate and the female at once begins to deposit her eggs.
3. **Damages.**
   a. They affect the fruit of the apricot, prune, plum and peach trees.
   b. They affect the above varieties by boring into the sap wood.

k. Peach twig borer.

1. The stages of development are like the peach tree borer.
2. There are two or three genrations during the summer.
3. **Damages.**
   a. Early in the spring as the foliage is putting out, the larvæ begin to leave their burrows and attack the tender leaves and shoots, boring into and down the pith.

b. The injured shoots soon wilt and die.
c. The larva enters the peach at the stem end boring into the pit, causing the stone to burst as the fruit ripens.
d. The larva may make its way to and around the stone, if split, it may enter and feed upon the seed.
e. The larvæ of the summer broods feed beneath the bark or in the fruit stem of the peach.

Order Dip'-te-ra (flies).

1. The adult insects have two wings.
2. The mouth parts are formed for sucking.
3. The metamorphosis is complete.
4. Study the external anatomy.
   a. **House fly.** b. **Mosquito.**
5. They are agents of disease.
6. Study the fungus gnat.
   a. It causes gall spots on leaves and twigs.

a. **Apple Maggot.**

1. The adult is a two-winged, black and white fly.
2. **Stages of development.**
   a. **The egg.**
      1. The eggs are deposited in June in the fruit by the female puncturing the skin with her sharp ovispositor.
      2. They hatch in a few days into maggots or larvæ.
   b. **The maggots or larvæ.**
      1. They make numerous channels in the pulp of the fruit.
      2. The infested fruit generally falls early.
      3. The winter is passed in larvæ state in the ground.
      4. The maggots crawl out of the fruit and enter the ground to pupate.
   c. **Pupa.**
      1. The pupa is enclosed in the last larva skin which serves as a cocoon.
      2. They emerge from their cocoon in June.
   d. They damage the fruit of the apple.
   e. They can be checked by fall plowing and destroying windfall apples by allowing hogs to run in the orchard.
3. Study the pomace fly.

Order Co-le-op'-te-ra (Beetles).

1. The insects have a pair of horny wing covers, beneath which there is a single pair of membrane wings.
2. The mouth parts are formed for biting.
3. The metamorphosis is complete.
4. Study the external anatomy.

a. **Flat-headed apple tree borer.**

1. The beetle is about ½-inch long and flattish oblong.

2. **Stages of development.**
   a. **The egg.**
      1. The eggs are deposited under the loose scales or within the cracks of the bark during the summer.
      2. The eggs hatch in a short time and the larvæ bore channels in the sap wood.
   b. **The larva.**
      1. It remains in the sapwood until shortly before pupation then it bores deep into the solid wood.
   c. **Pupa.**
      1. It takes from one to three years for the larvæ to change to a beetle.
   d. The beetles are steel colored, flattened above with irregular depression on the wing covers.

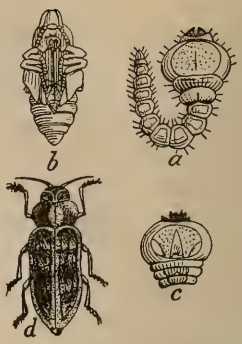


Fig. 157. — Flat-headed apple borer. a, the borer full grown; b, pupa; c, reverse side of the head; d, beetle.

3. These borers attack apple, pear, peach trees.
4. The presence of the larva may be detected by the discoloration of the bark or exudation of sap or sawdust castings.
5. They should be dug out of the trees.

b. **Round-headed apple tree borer.**

1. The beetle is about ¾-inch long.
2. It is brown and has two broad white stripes extending the length of the body.
3. **Stages of development.**
   a. It is similar to that of the flat-headed apple tree borer.
4. The borers tunnel into the inner bark and the sapwood, and also bore around the tree and girdle it.
5. It takes about three seasons for the larva to reach maturity.
6. They are very injurious to the young apple trees.
7. They are detected the same as the flat-headed apple tree borers.

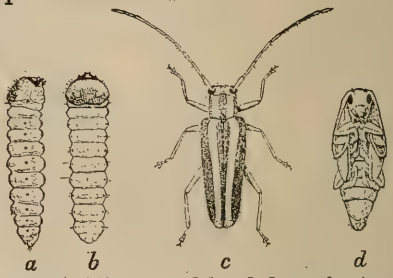


Fig. 158.—Round-headed apple tree borer. a, b, the larvae; c, the female; d, pupa.

c. **Apple Twig Borers.**

1. The beetle is about 1/3-inch long, cylindrical form, brownish above and black underneath.
2. **Stages of development.**
   a. It is similar to the flat-headed apple tree borer.
3. They attack the apple, pear, cherry, and other trees, and bore into the twigs just above a bud for food and shelter.
4. The infested limbs should be cut off and burned.

d. **Fruit Bark Beetle.**

1. **The stages** of development

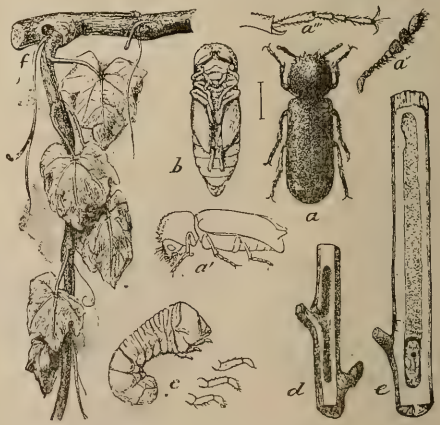


Fig. 159.—Apple twig borer. a, a, two views of beetles; b, pupa; c, larva; d, e, f, twig burrows.

are like the flat-headed apple tree borer.

2. **Damages.**
   a. They attack plum trees in preference to other plants.
   b. They infest the apple, peach, cherry, plum, pear, quince, apricot trees.
   c. The larvæ live beneath the bark where they feed upon the sapwood.
   d. The beetles generally infest the sickly tree.
3. The infested trees should be burnt.

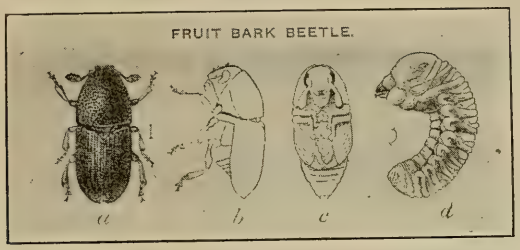


Fig. 160.—Fruit Bark-Beetle; a, adult; b, beetle in profile; c, pupa; d, larva.

e. Plum Curculio.

1. The beetle is about ¼-inch long, brown with grayish black spots.
2. The beetles leave the trees in the fall and hide away in secure places for the winter period of hibernation.
3. The beetles emerge from their hiding places in the spring when the vegetation begins to grow and the buds begin to push out.
4. The beetles mate about the time the trees begin to bloom and deposit their eggs when the young fruit begins to enlarge.

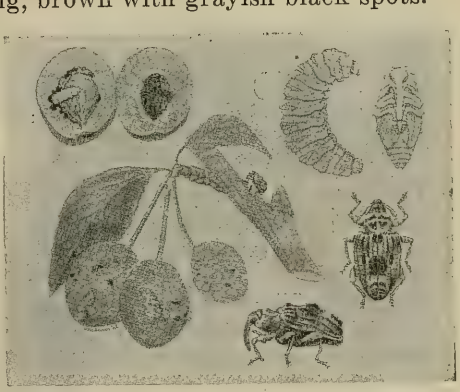


Fig. 161.—Plum curculio; shows larva, adult, pupa, infected plums.

5. **Stages of development.**
   a. **The egg.**
      1. The eggs are deposited during June, July and August.
      2. The eggs are deposited in the young fruit by puncturing the tissue and inserting the eggs.
      3. A crescent-shaped groove is cut around one side of eggs to prevent the growing tissue from crushing the eggs.
      4. The eggs are hatched in from 4 to 6 days.
      5. The beetles die after they deposit their eggs.
   b. **The larvæ.**
      1. The larvæ feed for about 20 days in the fruit, then they bore out of the fruit and enter the ground as matured larvæ.

c. **The pupa.**
   1. The larvæ remain in the ground for about 28 days and emerge as a perfect beetle.
   2. The larvæ are large white grubs.

d. **The beetles.**
   1. They remain quiet for a few days then they fly to the trees to feed on the fruit.
   2. The beetles of the new generation cause the greatest injury to the fruit crops.

6. **Damages.**
   a. The larvæ or maggots cause the fruit to drop before ripe and hard knots to form on the fruit.
   b. They affect apples, cherries, plums, peaches, pears and quince buds and leaves, and the larvæ bore into the fruit around the pit.
   c. The curculio of the apple, cherry, peach, pear, haws and quince are similar to the plum curculio.
   d. They may be caught and destroyed by jarring them off the tree into a sheet.

7. Note: Study the following:
   a. Plum gouges; b, Tiger beetle; c, Ladybug.

Order Hy-me-nop'-te-ra.

1. The insects have four membranous wings.
2. The mouth parts are formed for biting and sucking.
3. The metamorphosis is complete.
4. Study the external anatomy.
   a. Study the bee and wasp.

a. **Saw Fly.**

1. They belong to the order that has four wings of a delicate membranous texture.
2. The bees, wasps, and ants belong to the same order.
3. Study one of the above insects if a saw fly can not be secured.
4. **Stages of development.**
   a. **The egg.**
      1. The egg is oval in outline sometimes slightly flattened at one side.
      2. It is pale and almost colorless appearing light green through the leaf tissue.
      3. The eggs are deposited in the tissue of the leaves.

Fig. 162.—The eggs of a pear-slug or saw-fly. (Iowa Exp. Station.)

4. They are placed just beneath the epidermis of the upper side of the leaf by the female saw fly.

b. **The larva or slug.**

1. The young larva emerges from the egg to the upper surface of the leaf, cutting a semi-circular hole in the epidermis.
2. The body is pale, free from slime, the head is light brown and the thorax is broad.
3. The slug molts from five to seven times.
4. A coat of slime is secreted very soon after hatching and the slug then appears dark olive green in color, with a dark brown head.
5. The larvæ drop to the ground when they are molting for the last time.

Fig. 163.—The mature larva. (Iowa Exp. Station.)

Fig. 164.—Shows two cocoons of the pear slug. (Iowa Exp. Station.)

Fig. 165.— The pupa. (Iowa Exper. Station.)

c. **Pupa.**

1. The larva forms an earthen cell lined with sticky substance, making the particles of earth adhere.
2. The earthen cells are found one or more inches below the surface of the soil in summer; deeper for winter.
3. The larva pupates in 6 to 8 days after entering the cocoon if an adult saw fly is to emerge the same year; but if to emerge the next spring the larva remains as it is until spring, pupating just before emerging.

4. The adult saw fly emerges from the cocoon and deposits its eggs in the spring or summer.

d. **Adult saw fly.**
   1. It emerges in the spring from its winter cocoon which may be of the first generation or second generation.
   2. There is no proof that the saw flies mate.
   3. Note: Study
      a. The rose slug.
      b. Currant worm.

Fig. 166.—The adult saw-fly. (Iowa Exp. Station.)

5. **Numbers of generations.**
   a. There are two generations each year.

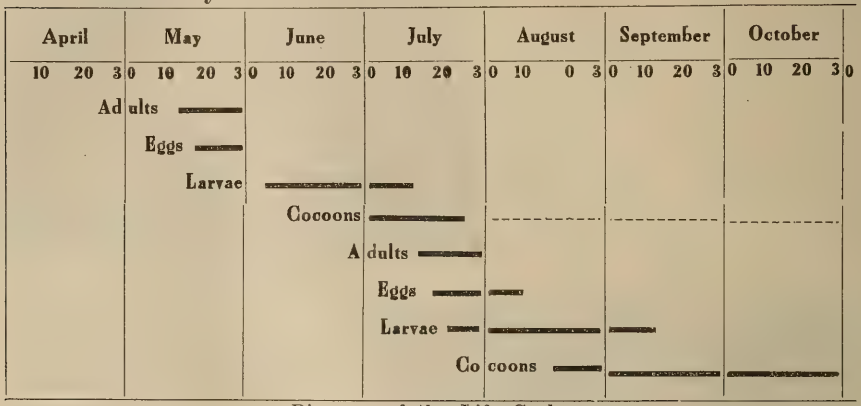


Diagram of the Life Cycle.

   b. **Study the above diagram.**
      1. Study when the flies of the different broods appear.
      2. Study when the larvæ of the different broods appear.
      3. Study when the pupation of the different broods takes place.
   c. **Life cycle from egg to egg.**
      1. From eggs to larvæ about 18 days.
      2. From larvæ to pupa about 19 days.
      3. From pupa to adult about 8 days.
      4. From adult to middle of egg-laying about 5 days.
      5. Total of about 50 days.

6. **Damages.**
   a. The larvæ feed upon the leaves of the pear, plum, cherry and quince.
   b. The slugs feed on the upper surface of the leaves, not eating holes through them, but taking the upper portion and leaving the vines bare.
   c. The injured trees appear as if they had been scorched by fire.
   d. The damaged leaves turn brown, curl up and finally fall.

Preventatives.

1. See spraying calendars.
2. Study the preventatives given in bulletins and in books.

References.

1. Manual for the Study of Insects by Comstocks.
2. Practical and Descriptive Zoology by Colton.
3. Practical Zoology by Davison.
4. Economic Entomology by Smith.
5. Fruit Growing in Arid Region by Paddock and Whipple.
6. Insects Injurious to Fruits by Saunders.
7. New Mexico Bulletins Nos. 35, 68.
8. Colorado Bulletins Nos. 112, 114, 152.
9. New York Bulletin No. 170.
10. Ohio Bulletin No. 164.
11. New Hampshire Bulletin No. 109.
12. Washington Bulletin No. 77.
13. Iowa Bulletin No. 130.
14. The Spraying of Plants by Lodeman.
15. Write to U. S. Dept. of Agriculture and to the different State Experimental Stations for bulletins on any of the above insects.

STUDY OF PLANT DISEASES.

Cryp'-to-gams.

1. **The Cryptogams.**
   a. They are seedless plants and are propagated by means of spores.
   b. The spore is a single organic body consisting of a single cell which separates from the parent plant at maturity and gives rise to a new individual.
   c. **Three great orders of the cryptogams.**
      1. **Thallophytes or thallus plants.**
         a. The thallus plant is the simplest kind of a vegetable structure.
         b. **Two divisions.**
            1. Algae, as seaweeds, pond scums.
            2. Fungi.
               a. Mushrooms, puffballs, molds, rust, mildew and lichens.
               b. Miscroscopic organisms, as bacteria.
                  1. Produces fermentations, putrification and disease.
      2. **Bryophytes or Moss Plants.**
         a. Mosses.
         b. Liverworts.
      3. **Pteridophytes or Fern Plants.**
         a. Ferns.
         b. Horsetails.
         c. Club mosses.
         d. The study of the cryptogams will aid in understanding the lower form of plant life and make the study of the fungi easier.

Plant Diseases.

1. The word disease may be applied to any unhealthy or abnormal condition in a plant which may be caused by faulty nutrition, fungi and bacteria.

2. **Any disease involves three things.**
   a. **A plant to be diseased.**
      1. Some varieties of plants are more susceptible to diseases than others.
      2. Vigorous and healthy trees resist the attacks of diseases while weak ones are susceptible to the attacks of disease.
      3. Trees that are injured by insects are susceptible to diseases.
      4. A plant upon which a parasite lives is called its host.
   b. **Environments.**
      1. Heavy dews and cloudy damp weather are favorable to the development of fungus diseases.
      2. The weather is very important and it sometimes is erroneously given credit for the diseases.
      3. Proper selection of an orchard site, and careful and thorough pruning will aid in preventing diseases.
      4. A site located on high land with good air drainage is less susceptible to disease and winter injury.
      5. A tree pruned to admit air and sunlight is less susceptible to disease.
      6. Good soil, good cultivation, good air drainage, and free from weeds are direct preventives to diseases.
      7. Things that help diseases.
         a. Weeds protect many diseases and pests during winter.
         b. Dead and dying branches in the trees.
         c. Old dying trees in young orchards harbor diseases and pests.
         d. Peach and pear trees in any apple orchard may carry brown rot, curculio, crown gall and pear blight.
   c. **Bacteria and fungi.**
      1. They belong to the lower forms of life and are very different from the familiar green plants in their manner of reproduction and in their method of obtaining food.
      2. Because of their lack of chlorophyll or green coloring matter they are unable to make their own starch and sugar good material and are compelled to depend upon other plants for the preparation of a large part of their nutriment.
      3. They feed upon both living and dead organisms.
      4. Those living upon dead organic matter are known as Saprophytes.
      5. The moulds that destroy stored vegetables and fruits are examples of saprophytes.
      6. Fungi that obtain their food from living creatures are known as Parasites.
      7. The vegetative portion of a fungus consists of minute threads known as Hyphæ (d).
      8. A mass of these hyphæ is spoken of collectively as the mycelium (b) which spread between or into the cells of the host and absorbs its food material from them.
      9. **Fungi form** no seeds but are reproduced by means of spores. (F).
         a. These serve the same purpose as seeds but are produced in

much greater numbers and are much more simple in structure.

b. They are too small to be seen with the eye and so light that they are readily scattered by the wind.

c. Spores may be divided into two classes, Fig. 167.

1. The summer spores (f) are produced in enormous num-

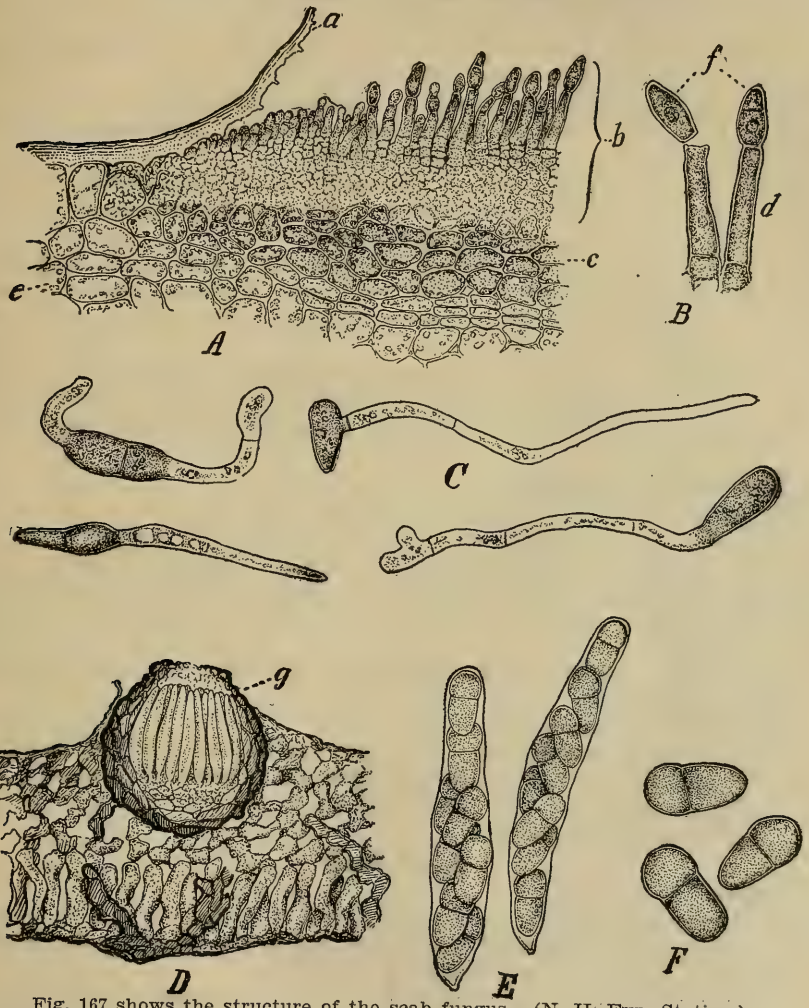


Fig. 167 shows the structure of the scab fungus. (N. H. Exp. Station.)

A. Portion of a section through a scab spot on an apple showing the fungus
1. a—The cuticle or rind of an apple.
2. b—Fungus spreading under and lifting the cuticle.
3. c—Partly disorganized cells of the apple.

B. Sporophores.
1. d—Two spores-bearings stalks (hyphae).
2. f—Summer spores cut off from the hyphae.

C. Spores germinating or hyphae.

D. Winter spores which have developed in an infected apple leaf which has lain on the ground over winter.
1. g—Perithecium, or spore case containing a bundle of spore sacs (asci).

E. Two spores (asci) each containing 8 two-celled winter spores.

F. Three two-celled winter spores.

bers and serve for the spread of the disease in the summer.

2. The winter spores (g) can endure more unfavorable conditions and serve to carry the disease over winter and through dry seasons.
3. The spores are usually produced in a protective body called Perithecium (B).
4. The spores that are produced in the perithecia are enclosed in a sac called Asci (g).

d. **The spores germinate** by sending out germ tubes (C).

1. This tube or hypha may enter the host tissue and develop a new mycelium there.

10. The breathing pores of the leaves and fruit and the wounds on the limbs and the trunk of the tree furnish opportunities to gain entrance to the host plant.
11. The fact that the spores can germinate only in the presence of moisture and that the germ tube is thin-walled and delicate, gives an opportunity to destroy it before it gains entrance to the host.
12. The host plant should be sprayed with some substance which will be poisonous to the germinating spores and which will slowly dissolve in the dew or other moisture that may be on the plant.

3. **The three preventatives.**

a. Trees themselves should be resistant.

1. They will resist if kept growing evenly and healthy.
2. They should have cultivation, pruning and fertilization.
3. Improper falling of leaves and buds growing in the fall are signs of improper nourishment and poor resistance to diseases.
4. Varieties that are in themselves resistant to diseases should be selected.

b. Proper environments.

1. Clean orchards, good drainage, fertile soil, good cultivation, and good nursery stock are essential to prevent diseases.

c. Spraying to kill the spores before they enter the host is the greatest preventative.

Apple Scab.

1. **Cause.**

a. Apple scab is due to the presence of a fungus which grows beneath the cuticle of the leaves and fruit, invading the superficial cells with its branching threads.

b. In a short time the fungus gives rise to groups of small stalks which break through the cuticle, or skin, and give forth numerous minute olive-colored spores.

2. **Description.**

a. The scab first appears early in the spring and these spores are scattered in April and May on the young buds and unfolding leaves, and new infections may continue to take place throughout the season.

b. Scabs are circular, rough, somewhat irregular in outline, grayish or olive green, becoming black when older, and range in size

from mere specks to spots one-fourth to one-half inch in diameter.

c. Two or more spots may coalesce, forming large, irregular scabby areas.

d. The ruptured skin of the apple usually persists around the margin of the spot, leaving a light-colored ring at the border of the healthy tissue.

3. **Spreads.**

a. These spores are blown about by the winds, and it is by means of these wind-dispersed spores that the infection takes place.

b. The fungus is carried over winter in the diseased leaves on the ground, where spores of the perfect stage are produced, which are discharged in early spring as the young leaves and fruit buds begin to open.

c. These winter spores start the infection which is further spread by the summer spores, soon produced by the new scab spots.

d. The first spread is early in the season and second spread is in August.

4. **Damages.**

a. It affects the fruit of apples, pears and quinces.

b. Young fruits affected with this disease may become pitted, one-sided, and otherwise distorted, and in severe cases the fruit becomes cracked.

c. The fungus may attack and destroy the blossoms and even the unopened buds; the flower stalks may become so weakened by the disease that the young fruit drops off.

b. Scabs are circular, rough, somewhat irregular in outline, grayish

e. The disease also appears on both sides of the leaves and on the leaf-stalks in the form of smoky brown patches, which become swollen and blister-like.

f. The winter spore stage on the leaves often causes the leaves to curl more or less and results in the premature shedding of the foliage.

g. The fruit crop suffers in moist localities a greater loss by far from the attacks of scab than from any other fungous disease.

h. It often affects 50 to 75 per cent of the crop over wide areas, and is not unfrequently responsible for total failures by killing the young fruits when in blossom or soon thereafter and by rendering the fruit too unsightly for the market.

i. Scab has a wide distribution, being exceedingly serious in the Pacific Northwest, except in the dry climates similar to that of Yakima.

5. **Cold storage scab.**

a. The scab spots that develop in cold storage are either from colonies that were too small to be seen on the fruit or from spores carried into the box with the fruit.

b. The scab fungus is checked in its growth by low temperature and of cold storage.

c. The black sunken spots develop on the fruit sometimes ¼ inch thick, before any break is made in the cuticle of the fruit.

6. **Study.**

a. Apple blotch.

b. Bitter rot.

7. **Preventatives.**

a. See spraying calendars.

Fig. 168, shows scab on cold storage apples.
(N. H. Exp. Station.)

Black Rot, Cankers and Leaf Spot.

1. **Cause.**

a. The above three diseases have been found to be due to a single fungus.

b. Disease of fruit is called black rot; of branches, cankers; of leaves, leaf-spot.

2. **Description.**

a. **Black rot.**

1. It is a dark brown or black in color, and affects the tissue of the fruits, causing them to be comparatively firm.
2. It generally starts at the blossom end, but may start on any part of the fruit.
3. It is primarily a rot of ripe fruit, but may be found on fruit several weeks before maturity.
4. The spots may develop very slowly until picking time, then it begins to spread rapidly till the whole apple is involved.
5. Numerous minute black elevations may be seen on the fruit as the rot develops; these bodies contain the spores of the fungus.
6. The worthless fruit is a breeding place for the spores.

b. **Canker.**
   1. Black-rot Canker is a term applied to the rough, unsightly diseased areas that are found on limbs.
   2. It destroys the bark and lays bare portions of the wood.
   3. It attacks the larger limbs where it may be detected by the swollen appearance of limbs, the rough, black bark and in many instances, bare wood, black and decaying.
   4. It may girdle the limb causing the part above the girdle to die.
   5. It is sometimes called the "New York apple tree canker."

c. **Leaf spot.**
   1. It attacks the foliage after the buds break, and the young leaves show small reddish-brown spots.
   2. When the leaves are full grown the spots are brown, brittle, circular and sharply defined outline.
   3. Several black specks about the size of a pinhead appear at the center of the spots.
   4. A secondary growth may start from the center spots.

3. **Spread.**
   a. The above diseases are spread by means of spores.

Fig. 169.—Shows the black rot canker. (N. H. Exp. Station.)

4. **Damages.**
   a. **Black rot.**
      1. It affects fruit of the apple, pear and quince.
      2. It causes the fruit to become hard and wrinkled.

   b. **Canker.**
      1. It affects the limbs of the apple, pear and quince.
      2. It interferes with the circulation of the sap and sometimes causes the tree to die.

   c. **Leaf spot.**
      1. It affects the foliage of the apple, pear and quince.
      2. This diseased condition causes the leaves to drop prematurely, frequently leaving the trees denuded in early autumn, six weeks or two months before the normal period of leaf fall.
      3. Trees thus deprived of their foliage cease activity, and as a result the fruit is small and not properly matured; the buds for the crop of the following year are weakened and in some

cases not fully developed, and the life of the tree is materially shortened.

4. These leaf diseases are partly responsible for the failure of the trees to produce crops, and for the early decline of the orchard.
5. **Preventatives.**
   a. Destroy all rotten fruit.
   b. Prune out all cankered limbs.
   c. Keep the orchard free from weeds and rubbage.
   d. See spraying calendar.

Black Knot.

1. **Cause.**
   a. It is caused by a fungus.
2. **Description.**
   a. It causes a swelling underneath the bark, finally rupturing it and developing a spongy texture covered with dark olive green mold.
   b. In this stage, the summer spores are produced.
   c. Later, the knot becomes hard with a black surface inside of which are matured winter spores.
   d. The winter spores escape late in winter or early spring.
3. **Damages.**
   a. It affects the plum, cherry and grape.
   b. It causes a peculiar black growth on the limbs, large branches and trunk of trees.
   c. It causes considerable damage to young trees and vines.
4. **Preventatives.**
   a. The infested parts should be destroyed.
   b. The winter knots should be destroyed before the spores escape.

Fig. 170.—Shows the black knot on a grape vine. (Cal. Exp. Station.)

Brown Rot.

1. **Cause.**
   a. It is caused by a fungus.

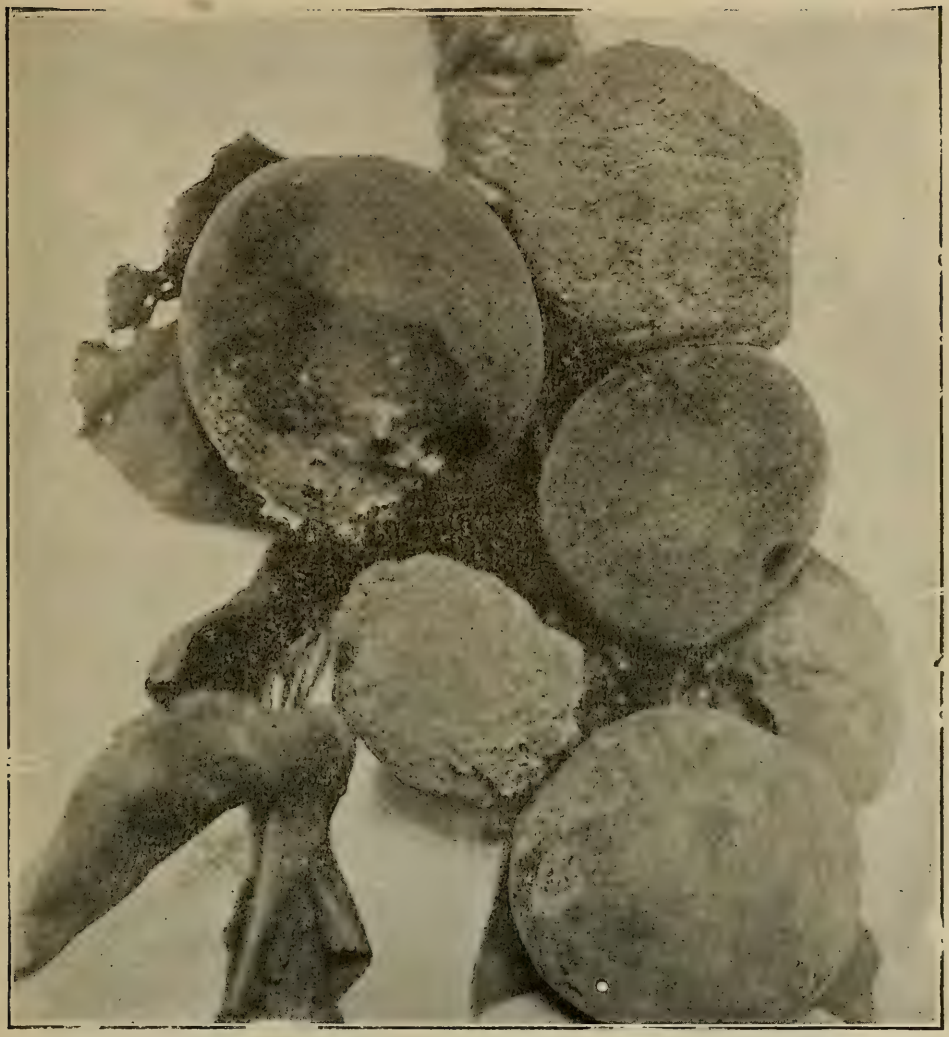


Fig. 171.—Shows brown rot of apricot. (Cal. Exp. Station.)

b. Warm and moist weather causes the spores to germinate readily.

2. **Description.**

a. It affects the stone fruits.

b. It causes the fruit to turn brown and rot, and develops on the skin a powdery brown coating.

c. The coating consists of a number of minute spores.

d. The germinating tubes penetrate the skin and develop a mass mycelium which destroys the tissue of the apple causing it to rot.

e. The spores remain in the fried up fruit until the following season when they start the disease again.

f. The spores also pass the winter in diseased branches.

7. **Preventatives.**
   a. See spraying calendar.

Crown Gall.

1. **Cause.**
   a. Crown gall is caused by bacteria and slime mold.
2. **Description.**
   a. It is an abnormal outgrowth and may appear on the trunk, at the crown, or anywhere on the roots.
   b. The knots are irregular in form, rough on the surface, soft and spongy within, and of various sizes.
3. **Two types.**
   a. Hard callous type.
      1. It is found on grafted trees at the union of the roots and scion.
      2. It is also found on root system where wounds are caused by cultivation or transplanting of trees.
   b. **Soft type.**
      1. It is found more common on seedlings but may be found on grafted stock.
4. **Hairy-root.**
   a. It has an excessive production of small fibrous roots originating in clusters from the main root.
   b. It is characterized both in seedlings and in grafted or budded trees by a stunted root system.
   c. Galls often occur in connection with hairy-root but are a result of wounds rather than a form of the hairy-root disease.
5. **Spread.**
   a. It is spread in the orchard from tree to tree by means of culture.
   b. It is spread by nursery stock.
6. **Damages.**
   a. It is fatal to all kinds of orchard trees.
   b. The knots are detrimental to the tree and when they occur at the crown, the tree is worthless.
   c. Trees being affected with crown gall produce inferior fruit.
7. **Preventatives.**
   a. Affected trees should never be planted.
   b. Avoid planting trees in soil that is infested by the disease.
   c. Apple trees should be removed from orchard when affected with the crown gall.

Fig. 172.—Crown Gall on apple root. (N. H. Exp. Station.)

Leaf Curl.

1. **Cause.**
   a. It is caused by a fungus.
2. **Description.**
   a. It affects the leaves and sometimes the twigs of peach trees.
   b. It causes the leaves to distort, crumple, and curl.
   c. It can be readily detected in the spring when the leaves first start.
3. **Preventatives.**
   a. See spraying calendar.

Fruit Rot.

1. **Cause.**
   a. It is caused by a fungus growing under the epidermis of the apple like A in Fig. 167.
   b. Mycelia containing spore sacs (Spermogonia) are developed under the epidermis and when the spore cases are matured, they break through the epidermis and discharge the spores.
   c. The thick walled spores are common in the apple and carry the disease over winter.

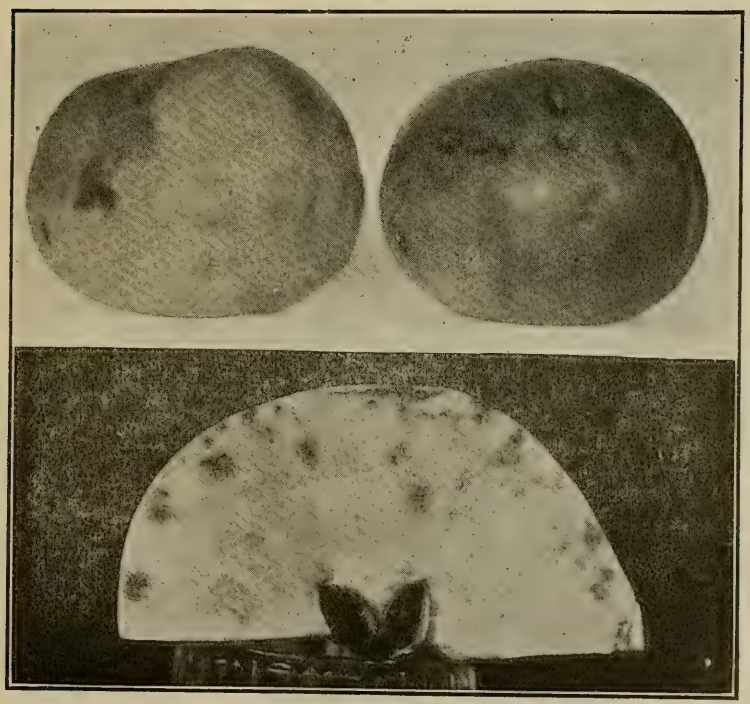


Fig. 173.—Shows the fruit spots of an apple. (Cal. Exp. Station.)

2. **Description.**
   a. First, the fruit spots may be seen as deep red on the colored surface of the apple and of a dark green on the lighter portion.
   b. As the spots become larger, they become slightly sunken and more colored.

c. Numerous black specks appear causing the center of the spot to have a black appearance.
d. The tissue beneath the spots is rendered brown and corky.
e. The disease is spread by the matured spore sacs discharging the spores on the surface of the apple.

3. **Damage.**
a. This fungus does not attack the fruit until nearly grown.
b. It causes the rottening of the ripening fruit of the apple, cherry, plum, apricot and peach.
c. This fungus may attack the twigs and blossoms when the weather is warm and moist.
d. The rotted fruit remains on the tree over winter in a mummied form and the following spring under favorable weather conditions becomes covered with spores by means of which the disease is propagated.

7. **Preventatives.**
a. Destroying all mummied fruits before growth starts in the spring.
b. See spraying calendar.

Fire Blight.

1. **Cause.**
a. It is caused by a bacterial disease which gains entrance to the tree through insect wounds or the flowers.
b. The insects are attracted by a dark, mucilaginous fluid that oozes from the diseased wood in the spring and which is swimming with bacteria.

Fig. 174.—Shows pear blight. (Cal. Exp. Station.)

c. The blight gains entrance to the tree in a majority of cases through the flowers, and as the flowers are borne upon spurs, and as these spurs are developed from wood which is one or more years of age.

2. **Description.**

a. It is known as the apple twig blight, blossom blight and pear blight.

b. It causes the leaves, blossoms and young fruit to wither, droop and turn black on the affected portions, remaining attached to the twigs during winter; but sometimes they may drop off when the leaves fall.

c. A tree that is severely attacked with the blight will often look as if a fire swept through the tree.

d. The infection is largely through the blossoms and proceeds down and through the inner bark of the twigs and branches.

e. The blight runs down into large limbs and remains alive over winter, producing the so-called "hold-over" blight, or canker, which is the source of the following season's infection. Fig. 174.

f. The blighted twigs, branches or trunks of a pear show a red, sappy, juicy condition of the inner bark.

g. It may creep back along the spur and form a blight canker on the tree.

h. It may kill the new shoots of the present year's growth.

i. The affected leaves and twigs turn black and finally die and sometimes the whole tree dies.

j. A dark mucilaginous fluid that oozes from the diseased parts forms beads of gum which is swimming with bacteria.

k. If one of the beads is put in a drop of water and examined under a microscope, it will be found to contain bacteria.

l. It may be found on the blossoms, twigs, watersprouts, stem, or any part of the tree.

3. **Spreads.**

a. The insects get some of the mucilaginous fluid on their feet or mouth parts and carry it from blossom to blossom where the bacteria multiply very rapidly.

b. It takes place through the

Fig. 175.—Shows the trunk of a pear tree that was treated for the blight.

blossom, tender shoots, or any wound on the tree.

c. The bacteria continue to spread by breaking down the cells of the cambium layer.

4. **Damages.**

a. It affects the blossoms, twigs, large branches and the trunk of the apple, pear, crab apple and quince trees.

b. It kills the blossoms, leaves, twigs and sometimes the entire tree.

c. The fire blight is formed in the growing season and if allowed to remain in tree, becomes "hold-over" blight or canker.

d. Fig. 175 shows the trunk of a pear affected with "hold-over" blight or canker.

1. The bark was peeled off the trunk and the trunk was treated for the blight.

2. Where the cambium layer was not injured the bark grew back.

3. The bare spot that is shown on the trunk is where the cambium layer was scraped off.

5. **Preventatives.**

a. The bacteria lies dormant during winter as "hold-over" blight or canker in the apple or pear tree.

b. The hold-over blight is often the result of late infections which do not develop very much in the fall.

c. The trees should be carefully pruned if there are any signs of the blight.

d. The cut in pruning should be made several inches below the lowest sign of the discoloration.

e. The pruning instruments should be sterilized with corrosive sublimate.

f. The wound or cut should be sterilized with corrosive sublimate.

g. It therefore becomes evident that if these fruiting spurs are allowed to remain upon the large structural branches of the tree, and the blossoms of such a spur become affected by the blight, the blight will immediately become communicated to the framework branch upon which the spur is situated.

h. It is evident that if the fruiting spurs which bear these blossoms are kept off the large branches of the tree there is less liability of injury to them from the blight.

i. Persons engaged in fruit culture should pay the strictest attention to the removal of all fruiting spurs from the main branches of the trees.

j. This will force the development of spurs upon the smaller branches, and as these can be allowed to develop at a considerable distance from the main body of the tree, contamination with the blight will only necessitate the removal of one of these smaller, minor branches, rather than the loss of a main framework branch.

k. By systematically cutting out all blighted branches which appear among the fruit-bearing branches of a properly pruned pear tree, it will at once rid the tree of the blight, without any serious detriment to the tree itself.

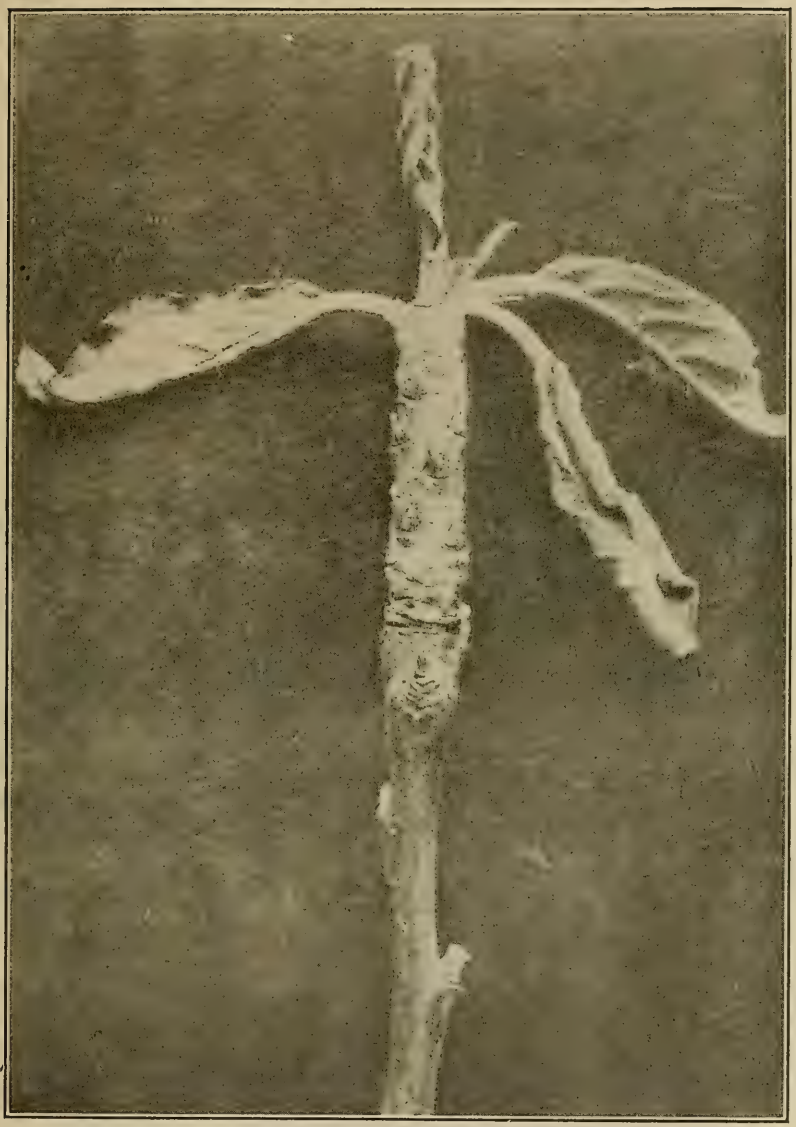


Fig. 176.—Shows apple twig affected by mildew. (Cal. Exp. Station.)

Mildew.

1. **Cause.**
   a. It is caused by a surface-growing fungus.
2. **Description.**
   a. The early stages appear as white frost-like patches on the leaves, twigs and fruit.

b. The leaves on new growths are most susceptible to attacks and are much crumpled and dwarfed.

c. It attacks fruit, making the flesh under the spots hard and the skin takes on a brown color.

3. **Damages.**

a. Mildew affects the twigs, leaves, and fruit of apple and peach trees.

b. It checks the growth of twigs or kills them outright.

c. The hardening of the flesh of fruit makes it unmarketable and sometimes the entire crop is ruined.

4. **Preventatives.**

a. See spraying calendar.

Root Rot.

1. **Causes.**

a. Several different fungi seem to cause this disease among which armillaria mellea is probably the most important.

b. The fungi that cause root rot of the fruit trees are generally called the "toad stool" fungi.

Fig. 177.—Shows the effect of root rot canker.

2. **Two types.**

a. The fungi that affect the roots.

b. The fungi that affect the stem.

3. **Description.**

a. The first indication is the appearance on the trunk and branches of dark brown spots caused by exudation of sap.

b. The bark dries down to the wood and has a dark color.

c. The disease causes a splitting of the bark.

d. The affected trees ripen their foliage early in the fall and the bark of the branches has a reddish cast.

e. The inner wood of the branches has a dark color.

f. The dead trees are found to be girdled just below the ground and the roots are decayed.

Russeting.

1. **Causes.**

a. By long continued cloudy, wet weather immediately after the setting of the fruit.

b. By spraying with Bordeaux mixture during cloudy wet weather.

c. By the freezing of the dew on the fruit while young.

2. **Description.**
   a. It affects the apple and the pear.
   b. The fruit shows areas on which the skin is rough, brown and corky.
   c. These areas may be irregular, in which case the fruit is said to be russeted, or it may form a definite area around the fruit, producing a condition called belting.

Fig. 178.—Shows sunburn on an apple trunk. (Cal. Exp. Station.)

Sunburn.

1. **Description.**
   a. The bark on one side of the tree dies and wounds are left on the tree.
   b. The wound becomes infested with a fungus which shows itself in a cluster of small bracket-like growths something like a toadstool.
   c. The fungus works into the sapwood of cambium.
   d. The apple is quite susceptible to winter sunburn injury of the trunk and branches.
   e. It is prevented by painting the trunk with whitewash; keeping the ground covered with vegetation or a mulch of some sort.

Apple Rosette.

(By F. A. Huntley.)

1. **Causes.**
   a. Apple rosette is a condition resulting from defective nutrition of the tree and may be caused by:
   b. Trees standing too close together, thus impairing both leaf and root action.
   c. Lack of soil fertility.
   d. Neglect of cultivation.
   e. Persistent shallow cultivation.
   f. A hardpan subsoil.
   g. A cold subsoil (occasioned by the presence of seepage or spring water).
   h. A water-saturated subsoil moisture.
   i. Insufficient subsoil moisture.
   j. Impaired soil drainage.

2. **Description.**
   a. The leaves on one or more branches of the tree fail to develop and have a yellowish appearance.
   b. The branches on which these leaves appear fail to elongate and

at a time of the year when they would normally have grown one to three feet, ordinarily, would make no terminal growth whatever.

c. The wood of the previous year's growth has failed to grow and has a sickly or shriveled appearance.

d. The bark of the tree is often yellowish; the cambium layer lacks vigor as is manifested at the top.

Fig. 179.—Shows both healthy and rosetted twigs.

1. Shows a healthy nursery twig one year old.
   a. Note the appearance of the buds.
2. Shows a rosetted nursery twig one year old.
   a. Note the appearance of the buds.
   b. Caused by poor soil and hard-pan a foot below the surface.
   c. Note that the terminal bud looks shriveled.

3-4-5 are taken from a bearing tree.

   a. They show that they bore leaves by the leaf-scars.
   b. They show no fruit buds or healthy leaf growth.
   c. They can never produce a terminal growth.
   d. The growth can only take place from lateral buds lower down on the twig.

3. Study Fig. 180.
   a. Note the healthy and rosetted twigs on the same branch.
   b. Note how the ends of the twigs are affected.
   c. The texture of the wood of a rosetted twig is found to be spongy when examined.
4. The improper nutrition may be caused by lack of available plant food.
5. The restriction of the root expansion may be caused by hard pan or a dry subsoil.

Fig. 180.—Shows healthy rosetted twigs.

6. Any injury to the structure of any part of the plant will hinder the function of the injured part; flow of the sap which carries the plant food from the roots to the leaves will be checked.
7. **Remedies.**
   a. Plant trees 30 feet apart each way to admit sun and air.
   b. Plow deeply every fall.
   c. Fertilize the soil with stable manure or plowing under green crops in the spring following deep fall plowing and seeding.
   d. Provide free drainage to a depth of at least four feet.
   e. Irrigate to the full depth and throughout the expansion of the root system.
   f. Irrigate seldom but thoroughly.
   g. Practice surface cultivation throughout the entire spring and summer.

SPRAYING.

1. **Important principles.**
   a. The habits and characteristics of each insect and fungus should be studied.
   b. A study of the different varieties of fruits as to their susceptibility to fungi and insects.
   c. A knowledge of how to protect the susceptible varieties from fungi and insects.
   d. A knowledge of the inter-relation between crops and fungi and insects.
   e. A knowledge of how to care for orchards and to watch for new pests.
   f. A study of how fungi and insects are distributed.
2. **Objects of spraying.**
   a. It is to kill the fungi and insects directly.
   b. It is to coat the plant with poison which will kill the orchard pests.
   c. It is to give a better quality and greater quantity of fruit.
3. **The blooming periods depend on:**
   a. Location as to latitude and altitude.
   b. Site as to air and water drainage.
   c. Exposure as to winds and frost.
   d. Soils: Black loamy, late; Sandy, early.
   e. The blooming period in some localities will be earlier, and other localities later than given in the following table, but the same relative time will exist between the different varieties as given in the table.
4. The space between the X's indicate the blooming period.

a. **Early apple bloomers.**

Date. / Name.	APRIL. 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Canada Sweet											X													X
Early Strawb'ry										X														X
Fallawater									X														X	
Graveinstein							X												X					
Haas						X												X						
Mann											X										X			
Duch. of Old'brg							X												X					
Ortley											X													X
Red Astrachan							X												X					
Stark											X								X					
Transc'd't Crab	X										X													
Wolf River											X													X
Wealthy										X											X			
Whitney Crab									X															X

b. **Late apple bloomers.**

Date / Name	APRIL 16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	MAY 1	2	3
Arkansas Black					X								X					
Bailey's Sweet			X										X					
Beitigheimer	X										X							
Ben Davis		X										X						
Baldwin								X								X		
Canada Red	X													X				
Fameuse			X							X								
Gano							X									X		
Grimes Golden				X								X						
Hyslop Crab	X							X										
Hyde's King					X							X						
Hoover			X													X		
Jonathan							X										X	
King of Tompkins County		X												X				
Mammoth Black Twig			X										X					
McMahon's White			X									X						
Maiden's Blush					X										X			
Yellow Newtown					X												X	
Northern Spy							X									X		
Pewaukee			X										X					
Rhode Island Greening					X											X		
Rome Beauty							X											X
Rambo					X											X		
Red Cheek Pippin					X									X				
Spitzenberg					X											X		
Salome	X											X						
Shiawassee		X									X							
Sweet Bough			X										X					
Tolman Sweet							X										X	
Walbridge					X													
Wagener			X													X		
Winesap					X												X	
York Imperial							X										X	
Yellow Transparent					X							X						

c. Early pear bloomers.

Date / Name	MARCH 29	30	1	2	3	4	5	6	7	8	APRIL 9	10	11	12	13	14	15	16
Clairgeau								X							X			
Keiffer	X														X			
Lincoln								X								X		
Lawrence								X								X		
Le Comte	X										X							

d. Late pear bloomers.

Date / Name	APRIL 8	9	10	11	12	13	14	15	16	17	18	19	20
Anjou	X					X							
Anjouleme		X						X					
Clapp's Favorite					X						X		
Easter Buerre	X								X				
Flemish			X					X					
Howell	X							X					
Idaho						X						X	
Seckel				X					X				
Tyson		X										X	
Vicar	X					X							
Winter Nellis		X									X		

e. Early cherry bloomers.

Date / Name	MARCH 31	1	2	3	4	APRIL 5	6	7	8	9	10	11	12	13	14
Early Purple Guigne	X										X				
Elton						X								X	
Lincoln			X									X			

f. Late cherry bloomers.

Date / Name	APRIL 8	9	10	11	12	13	14	15	16	17	18	19	20	21
Morello				X							X			
May Duke						X								X
Montmorency			X						X					
Royal Ann (Napoleon)			X									X		

g. The blooming period of each variety should be studied and tabulated for each locality.

h. The blooming period is important as upon which depends the time to give the different sprays and also the development of the fungi and insects.

5. **How to spray.**
   a. Spray thoroughly.
   b. Direct your attention to the hardest places to reach.
   c. Cover every surface and wet behind the buds.
   d. Reach the bottom of every crack and fill each lower calyx cup.
   e. Do not try to economize on spray.
   f. Use a high-pressure pump (at least 200 lbs.).
   g. Use Bordeaux nozzels only and an 8-foot spray rod.
   h. Have a crook to set the nozzles at an angle of 43 degrees.
   i. Spray from a tower if the trees are beyond your reach.
6. **How to give the calyx spray.**
   a. Washington Bulletin No. 45.
7. **The best spray poison.**
   a. Washington Bulletin No. 45.
   b. Washington Bulletin No. 28.
   c. Washington Spray Calendar.

8. Apple blossoms.

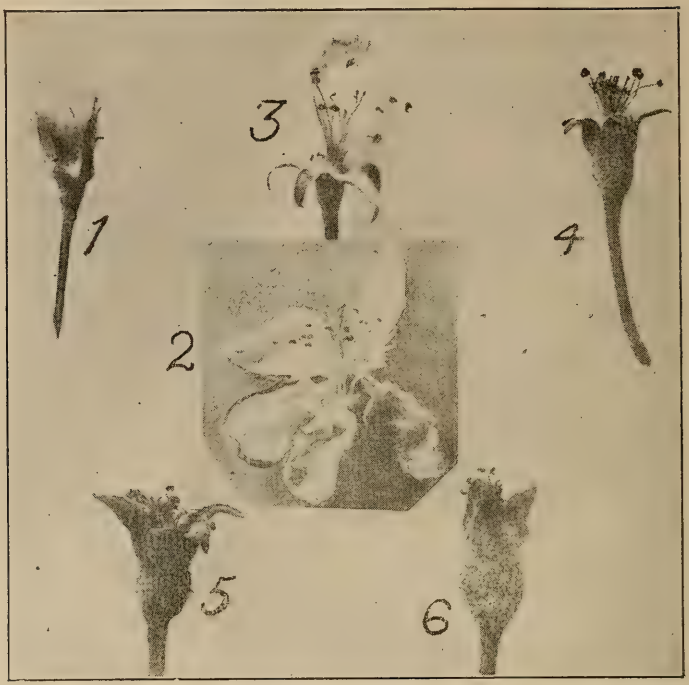


Fig. 181.—Shows the apple blossom in different stages of development. (Neb. Exp. Station.)

a. 1 shows a cluster bud before opening (first spray) for fungi.
b. 2 shows a cluster bud opened (wrong time to spray).
c. 3 shows the flower after petals have dropped off (first spray for codling moth and curculio) and also second spray for fungi.
d. 4 shows the calyx lobes beginning to close (second spray for codling moth).
e. 5 shows calyx lobes almost closed (somewhat late for second spray for codling moth).
f. 6 shows calyx lobes closed (no poison can enter the calyx cup).

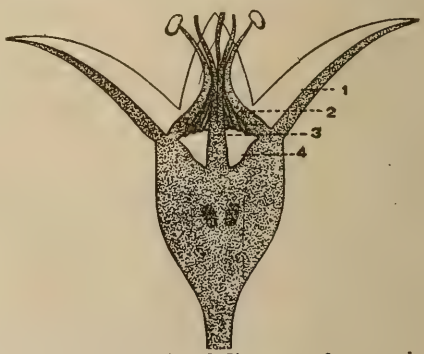


Fig. 182.—Sectional diagram of an apple blossom.

9. Parts of the blossom. Fig. 182.
a. 1 shows the calyx lobes.
b. 2 shows the stamens.
c. 3 shows the pistil.
d. 4 shows the calyx cup.
e. Study figure 65.
f. The central or terminal bud in each fruit cluster is generally the first one to open its bloom.
g. Its petals are first to drop and the central blooms generally set the best quality of fruit.
h. Calyx cup. Fig. 182.
1. The calyx cup is in the center of the flower around the pistil.
2. It is hidden from view by the stamens.
3. The stamens must be forced apart by the spray in order to reach the calyx cup.

4. The spray must fill the calyx cup in order to kill the insects that crawl into the calyx cup.
5. The poison generally remains in the calyx cup throughout the season.
6. The first spray will kill the codling moth and curculio.
7. The spray on the outside of the apple will wear off and must be renewed.

10. **Calyx condition.** Fig. 183.
   a. The left shows calyx lobes open and some more closed than others; right time for first spray.
   b. The right shows calyx lobes closed and almost too late for first spray.
   c. The direction of the calyces should be kept in mind.
      1. One-third of the calyces should point downward.
      2. Two-thirds of the calyces should point upward.
      3. Some, of course, will point in all directions.
      4. The calyces on the center and top will generally point upward.
      5. The calyces on the limbs will generally point downward.
      6. The center and top calyces will close first.

Fig. 183.—Shows a cluster of young apples.

Plans of Treatment.

1. **Fall spraying.**
   a. Spray just after the leaves fall.
   b. What to spray for and how.
      1. See spraying calendar, or,
      2. Sulphur lime calendar.
2. **Winter spraying.**
   a. Spray while buds are swelling.
   b. What to spray for and how.
      1. See spraying calendar.
      2. See sulphur lime calendar.
3. **Spring spraying.**
   a. Spray when flower buds are ready to open.
      1. What to spray for and how.
         a. See spraying calendar.
         b. See sulphur lime calendar.
   b. Spray while the last blossoms are falling.
      1. What to spray for and how.
         a. See spraying calendar.
      2. It is rare that a moth emerges from its winter-pupa-case before most of the petals have fallen; often it does not take place until a week or two after this time.
      3. The moths mate and eggs are laid in a day or two, which hatch in about 8 days (first brood of worms).
      4. The object of spraying is to coat the food of the newly hatched worm with poison.
      5. Since most worms attack the apple at the blossom end, it is necessary to fill this part of the fruit with poison.

6. This can be done only during the week or ten days immediately following the blossoming period, before the calyx lobes fold over.
7. Sometimes for the sake of thoroughness, the calyx spraying is repeated a few days later.
8. While the first spraying primarily aims to fill the calyx cup, it coats the outside of the apples and leaves as well.
9. This exterior poison reduces the number of side entering worms of the first brood.
10. At this time one spraying may be sufficient, if thoroughly done, depending upon the number of calyx cups which are open in condition to receive the spray and the number which examination proves to have been penetrated by the spray.
11. The trees should be banded and observed whether many or few worms are trapped; bands catch about one-half of the worms.
12. The first or calyx spray is given sometime before the first brood of codling worms appear.
13. By the time the eggs are hatching, the young apples will have grown considerably and a second or even a third spray may be deemed necessary to coat the apples.
14. The above constitutes the first or calyx spray for the codling moth.
15. **Summary of sprays for codling moth.**
    a. First or calyx spray—just after the blossom petals fall; there may be one, two or three sprays at this time.
    b. Second—about three weeks later.
    c. Third—from July 15 to Aug. 10, depending upon season and locality.
    d. Fourth—about one month later.

c. Other sprays.
1. See spraying calendar.
2. See sulphur lime calendar.

4. **Summer spraying.**
a. Spray when pest appears.
1. What to spray for and how.
a. See spraying calendar.
b. See sulphur lime calendar.

5. **References.**
a. Washington Bulletins Nos. 28, 45, 81.
b. Idaho Bulletin No. 55.

A SULPHUR-LIME SPRAYING CALENDAR.

When to Spray	What to Spray For.	Suggestions.
When buds are swelling. Spray with force. Use the Bordeaux nozzle and a crook. Spray down from above the branches. Wet behind the buds.	San Jose scale. Oyster shell scale. Blister mite. Any scale insects.	
	Moss. Lichens.	
	Green aphis.	This treatment for the eggs is more effective than summer sprayings with tobacco or kerosene emulsion.
	Bud moth. Peach twig borer.	If insects appear later apply arsenate of lead.
	Woolly aphis.	The wool must be wetted through.
	Peach leaf curl.	
	Peach mildew. Apple mildew. Grape mildew. Rose mildew. Gooseberry mildew.	If mildews appear during summer apply sulphur-lime immediately.
Just before blossoms open.	Apple scab. Pear scab.	This checks most of the scab. Where there is much scab we suggest a spraying as soon as the blossoms fall.
When the pest appears.	Red spider. Young of oyster shell scale.	Use half strength with Blackleaf 40, 1 to 1000, and fishoil soap added.
	Aphis.	
	Grasshoppers. Cutworms. Flea beetles.	As a repellant.
	Sheep scab. Sheep ticks.	Dip the sheep.
Keep the trunks coated all summer.	Trunk and bark borers.	Add strong sulphur-lime to a thick whitewash of slaked lime.
Keep the trunks coated all winter.	Rabbits and field mice.	
As soon as the leaves fall.	Black spot canker.	Repeat in two weeks.
Frequently during the summer.	Typhoid fly.	Spray manure piles and privies for fly maggots.
	Chicken mites and lice.	Spray the roosts and the insides of chicken houses.

ORCHARD SPRAYING CALENDAR FOR 1913

Prepared by A. L. Melander, Entomologist, and H. B. Humphrey, Plant Pathologist.

For information about insects, pests, plant diseases and spraying write to the Washington State College, Pullman, Washington.

Affecting the Roots.

NAME.	DESCRIPTION.	TREATMENT.
1. Woolly aphis	Small galls containing mealy insects	Expose roots and wet with one per cent potassium cyanide solution, or tobacco.
2. Grubs and wireworms	Feeding on the roots	No available spray treatment. Seek out and destroy insects.
3. Gophers	Feeding on the roots	Trap; or poison with raisins containing strychnine placed in runways.
4. Hairy-root	Excessive development of fine roots from some part of a larger root	No remedy except careful nursery inspection.
5. Crown gall	Smooth to warty swellings from size of a pea to that of a cocoanut	No remedy except careful nursery inspection.
6. Crown-rot	Dead, sunken bark at crown of tree	Avoid forcing growth of young trees.

Affecting the Crown or Trunk.

7. Rabbits and field mice	Gnawing bark in winter	Keep trunk coated throughout winter with thick whitewash containing strong sulphur-lime.
8. Borers	Tunneling beneath bark or into heartwood	Keep trunk coated throughout summer with thick whitewash containing strong sulphur-lime.
9. Canker	Irregular, discolored sunken areas usually cracked around edges	No remedy when these cankers are due to winter injury. If black-spot canker, November spraying of 3° sulphur-lime.
10. Black-heart	Heartwood dead and stained blackish brown	No remedy known.

Affecting the Branches and Twigs.

NAME.	DESCRIPTION.	TREATMENT.
11. San Jose scale	Ash-gray or black, round scales, pinhead in size. (Many broods a year.)	Oil spray or sulphur-lime about March 1.
12. Oyster-shell bark-louse	Slender bark-colored scales filled with eggs, which hatch about June 1. (One brood a year)	1. Tobacco when young are hatching (about June 1). 2. Sulphur-lime (3°), or oil spray, in fall or spring.
13. Woolly aphis	Clusters of mealy lice, often near injured bark. When crushed give a red juice	Tobacco spray.
14. Orchard mite eggs	Microscopic salmon-red spherical eggs	Oil spray.
15. Aphis eggs	Minute oval jet-black eggs (winter)	Oil spray or sulphur-lime, 3°; or tobacco when plant-lice hatch.
16. Tent caterpillar eggs	Frothy mass encircling a twig	Oil spray, or arsenical when caterpillars hatch.
17. Lecanium	Hemispherical brown scales	Oil spray, or tobacco when scales hatch.
18. Cottony scale	Brown scales that develop cottony mass in the fall	Oil spray.
19. Cicada and tree cricket	Twigs slit to contain eggs	Prune off infested twigs before eggs hatch.
20. Bark beetle	Tunneling under bark	Not likely to attack vigorous trees. No immediate treatment.
21. Lichens	Popularly known as moss	Winter spray with sulphur-lime, 3°.
22. Gummosis of cherry	Glistening mass of amber-colored gum oozing from branches	Caused by scale, bacteria, aphis, over-irrigation, etc. Remedy depends on cause.
23. Fire-blight of pear and apple	Dead leaves and fruit hanging to blighted branches; blackish, water-soaked cankers	Prune away dead or blighting branches and wash pruned surfaces with 1 part of cor. sublimate to 1000 parts water.
24. Winter-kill or die-back	Death of twigs or branches from tip downward; no cankers	No remedy. Remove dead wood.
25. Peach blight	Spotting of green twigs and formation of a gum	Prune out dead twigs. Spray in winter with oil emulsion.

Affecting the Buds, New Leaves or Blossoms.

26. Bud-weevils	Hard-shelled beetles that drop when disturbed	Use inverted cone tree-protector of stiff paper or tin.
27. Cutworms	Work at night; live in ground during day	Coat tree with Bordeaux. Place spoonful poison mash on ground near tree.
28. Ants	Eating buds, young leaves, and blossoms	Pour one per cent potassium cyanide solution in nest (deadly poison).
29. Budworm; twig-borer	Working in terminal growth furling leaves	1. Oil spray or sulphur-lime, 3°, when buds swell. 2. Arsenate lead when injury noticed.
30. Snapping beetle	Feeding in the blossoms	No treatment.
31. Chafer beetle	Eating through the blossoms	No treatment.
33. Thrips	Minute, active, slender insects	Tobacco.

Affecting the Foliage.

NAME.	DESCRIPTION.	TREATMENT.
34. Tent caterpillars	Working from web-nests	Spray as soon as caterpillars appear with arsenite zinc, or burn with torch.
35. Tussock moth	Caterpillars covered with bunches of hairs	Spray as soon as caterpillars appear with arsenite zinc.
36. Red-hump caterpillar	Striped caterpillars with red head and collar	Spray as soon as caterpillars appear with arsenite zinc.
37. Grasshopper		Spray with Bordeaux.
38. Climbing cutworm		See No. 27.
39. Pear and cherry slug	Slimy caterpillars feeding on upper surface	Spray with arsenate lead; or dust with lime, ashes, or road dust.
40. Black aphis	On cherry	Spray early with tobacco.
41. Green aphis—Pink aphis		Tobacco (summer), or sulphur-lime, 3° (winter). See No. 15.
42. Blister-mite	Red, brown to black spots; on pear	No summer treatment. Oil spray or sulphur-lime when dormant.
43. Leaf hopper—Tingis	Sucking insects producing yellow spots in leaves	Tobacco spray. Use high pressure and disk nozzle to form mist.
44. Orchard mite	Causing leaves to yellow	Tobacco when noticed. See No. 14.
45. Peach leaf-curl	Leaves puckered, becoming rose-colored or purple	Spray in winter and early spring before leaves appear; use sulphur-lime.
46. Powdery mildew	Whitish patches on leaves, twigs and fruit	Spray with 1 part commercial sulphuric acid to 1000 parts of water.
47. Rosette	Cessation of twig growth and massing of leaves in rosettes	No remedy known.
48. Shot-hole diseases	More or less regular brown spots on leaves, later falling out	Spray with sulphur-lime during dormant season.

Affecting the Fruit.

I. Infesting the Outside of the Fruit:		
49. San Jose scale	Usually surrounded by red ring	No summer treatment. See No. 11.
50. Oyster-shell scale	Shaped like miniature mussel-shell	No summer treatment after scale is formed. See No. 12.
51. Caterpillars	Several species may nibble on skin	Arsenate of lead as soon as injury is noted.
52. Apple scab	Dull greenish-black patches on leaves or fruit	Spray with sulphur-lime, 1½°, just before blossoms open, and repeat after the petals fall. Destroy all dead and fallen, diseased leaves.
53. Brown rot of prunes	Small circular brown spots, later giving rise to spore-tufts	Destroy all mummied fruits following an outbreak of the disease.
54. Fruit spot of apricot	Brown, hard sunken spots or elevations	No remedy known.
55. Baldwin speck; fruit spot	Skin spots appearing before harvest working into fruit	No sure remedy known.
II. Infesting the Inside of the Fruit:		
56. Codling-worm	The common worm in apple or pear	Use Bordeaux nozzle with a crook, and spray with force from a raised platform directly into every flower. Repeat immediately. If so applied, these sprayings are usually sufficient. Keep a few trees banded. If many worms are trapped, spray. Write for codling moth bulletin.
57. Peach worm	Same insect as twig borer	No satisfactory summer treatment.
58. Apple saw-fly	Green caterpillar mining in fruit	No known treatment.
59. Water core		Do not leave too long on trees.

SULPHUR-LIME.

Sulphur, 1 pound; Fresh stone lime, ½ pound; Water, ½ gallon.

Slake the lime in the cooker. Add the sulphur and the water. Boil briskly till the sulphur is dissolved (about 45 minutes), stirring continuously and keeping the cooker covered. As it boils down keep adding water. When finished let settle. Use only the clear liquid, which may be stored if kept from the air. Prepared in this way sulphur-lime should have a hydrometer reading of about 26 degrees, but little weaker than the factory-made product. Write for bulletin on sulphur-lime.

For use, any concentrated sulphur-lime may be diluted according to the following table:

Hydrometer test of concentrate.		To make dilute spray.	
Beaume Degrees.	Specific Gravity.	Beaume, 3° Sp. gr. 1.02 1 lb. sulphur in 5 gal. Winter spray.	Beaume, 1.5° Sp. gr. 1.01 1 lb. sulphur in 10 gal. Summer spray.
34	1.302	1 to 14 water	1 to 28
32	1.279	13	26
30	1.259	12	24
28	1.236	11	22
26	1.215	10	20
24	1.196	9	18
20	1.158	7	14
16	1.122	6	11

OIL SPRAY.

Crude oil emulsion for winter spraying: **Fish-oil soap, 10 pounds** (dissolved in 10 gallons hot water; **Lye, 2 pounds** (dissolved in 1 gallon water). Mix, add water to make 88 gallons; run agitator at full speed, and add **Crude oil, 10 gallons.** When emulsified do not add anything else to the spray liquid, or free oil will separate.

TOBACCO.

Blackleaf 40, 12½ pounds; Fish-oil soap, 35 pounds; Water, 1000 gallons. Dissolve the soap in hot water. Blackleaf (old style) is one-tenth as strong. For orchard mites or scab add 36 gallons of 32° sulphur-lime.

BORDEAUX.

Bluestone, 6 pounds; Good lime, 4 pounds; water, 50 gallons. Dissolve the bluestone by suspending it in a sack in 25 gallons of water in a barrel. Slake the lime in another vessel, adding a little water slowly, and dilute to 25 gallons. Mix the two thoroughly. Even the best Bordeaux may scorch in rainy weather.

POISON MASH.

Bran and flour, 25 parts; Paris green or zinc arsenate, 1 part. Mix dry, add water to form a stiff mash and season with stale beer or molasses.

ARSENATE OF LEAD.

Arsenate of lead (poison), 1 pound; water, 50 gallons. For newly hatched insects it is not necessary to use it stronger. For old or large insects use double the quantity. Mix the paste well with a small amount of water. Powdered arsenate of lead is about twice as strong as the paste. Do not use arsenate that settles quickly or feels gritty. Arsenite of zinc powder is about four times as strong as paste lead. It may scorch in a damp season.

SPRAYING PROGRAM FOR THE MORE USUAL SPRAYINGS.

1—When buds begin to swell—Oil spray or sulphur-lime (3°), for scales and insect eggs.

2—When new foliage is first appearing—Tobacco, for aphis, orchard mites, thrips, leaf hoppers. With arsenate added for budworm, twig-borer.

3—When flower clusters are ready to open—Sulphur-lime (1.5°), for apple and pear scab. With tobacco added for orchard mites, thrips, aphis.

4—When last petals are falling—Arsenate of lead, 1 lb. to 50 gal., for codling moth.

5—In November (for Western Washington)—Sulphur-lime (3°), for black-spot canker and general clean-up.

Additional summer sprayings may be needed, as for codling moth, aphis, young oyster shell scales, orchard mites, etc

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